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TABLE OF CONTENTS

Vol. 19 June, 1936 No. 6

THE JOURNAL OF THE AMERICAN CERAMIC SOCIETY

The Fluxing Effect of Feldspar in Whiteware Bodies 159
By Edward Schramm and F. P. Hall

The Microbiology of Clays. I 169
By Dudley P. Glick

Some Data on the Influence of Firing Time on the Properties of Some Whiteware Bodies 175
By Arthur S. Watts

Kinetics of Some Reactions of Interest to Ceramists 177
By C. C. Furnas

CERAMIC ABSTRACTS

Vol. 15 No. 6

Abrasives 171
Art and Archeology 172
Cements 173
Enamel 173
Glass 174
Structural Clay Products 180
Refractories 180
Terra Cotta 183
Whiteware 183
Equipment and Apparatus 184
Kilns, Furnaces, Fuels, and Combustion 186
Geology 188
Chemistry and Physics 190
General 193

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THE FLUXING EFFECT OF FELDSPAR IN WHITEWARE BODIES*

By E. Schramm and F. P. Hall

Abstract

A review is given of literature dealing with the melting relations of the feldspars, the solubility of quartz and clay in feldspar, the use of feldspar in bodies, and the direct determination of viscosity. An experimental study is reported, based on the determination of vitrification curves and viscosity at high temperature for several types of bodies, employing different typical feldspars alone and in mixtures. Various potash feldspars give similar results when allowance is made for free quartz content. The action of several natural feldspars of intermediate soda content was duplicated with chemically identical blends of pure microcline and pure albite. The validity of chemical control is confirmed. The action of feldspar is best considered, not as a simple melting and solution process, but as providing a source of fluxing elements needed to bring about glass-forming reactions.

I. Introduction

Feldspar is the universal flux in the production of whiteware, and the question of the nature of its action may be considered the central problem of whiteware technology. As such, it has been studied in one aspect or another by numerous workers, but the literature records many contradictory conclusions. Some experiments will later be described which may contribute to an understanding of the problem, but to place these in their correct perspective it seems necessary to present first a review of recent literature.

II. Review of Literature

(1) Melting of Potash Feldspar

A comprehensive investigation of the isomorphism and thermal properties of the feldspars was carried out by Day and Allen,[1] who noted the sluggishness of melting and the high viscosity of orthoclase above its melting point, 1200°C. They regarded this as due to a residual crystallinity in the melt. It has been clearly shown, however, by Morey and Bowen[2] that the crystals are leucite ($KAlSi_2O_6$) and that they are the result of incongruent melting of orthoclase ($KAlSi_3O_8$), which starts to decompose at 1200°C into leucite, and a silica-rich glass. With increasing temperature the crystals become better developed but fewer in number. Complete melting is reached at 1530°C.

(2) Potash-Soda Feldspar Relations

Since the natural feldspars of interest in ceramics are essentially mixtures of potash and soda feldspar, the melting relations of this series have had much study. Watts,[3] by cone deformation studies, finds a eutectic near 70% albite and 30% microcline. Martz[4] carried out a similar investigation on the three-component system, potash feldspar, soda feldspar, and soda-lime feldspar. The lowest fusing mixture contains 30% Canadian potash feldspar, 60% Maryland soda feldspar, and 10% North Carolina soda-lime feldspar. Recalculated on a theoretical basis this represents 25% microcline, 70% albite, and 5% anorthite. In the binary series, potash–soda-lime feldspar, a eutectic is obtained with 27½% of the soda-lime feldspar. In the plagioclase series, soda–soda-lime feldspar, no eutectic is observed, but an increase in deformation temperatures from the soda to the high lime end.

Schairer and Bowen[5] report the results of equilibrium studies on the alkali feldspars (Fig. 1). The incongruent melting observed by Morey and Bowen for microcline persists in the microcline-albite series up to 53% albite, although the temperature of complete liquidity falls with increasing proportions of albite. The leucite field is of wide extent. The data are interpreted as representing a complete series of solid solutions between microcline and albite with a minimum melting temperature at 70% albite.

(3) Feldspar-Quartz-Clay Relations

Some of the earlier workers reported the existence of a deformation eutectic in the feldspar-quartz system, but the consensus of recent work indicates the absence of any eutectic either in the feldspar-quartz or feldspar-clay systems. A cone-deformation diagram of the three components after Simonis is given in the Compilation of Phase-Rule Diagrams by Hall and Insley.[6] Amberg and Gallup[7]

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* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division).

[1] A. L. Day and E. T. Allen, "The Isomorphism and Thermal Properties of Feldspar," *Carnegie Inst. Wash. Pub.*, No. 31 (1905).

[2] G. W. Morey and N. L. Bowen, "The System $KAlSi_2O_6$–SiO_2," *Amer. Jour. Sci.* [5] **4**, 1–21 (1922).

[3] A. S. Watts, "Feldspar and a Deformation Study of Some Feldspar and Feldspar-Quartz Mixtures," *Trans. Amer. Ceram. Soc.*, **15**, 144 (1913); see also Fig. 162, *Jour. Amer. Ceram. Soc.*, **16** [10] 556 (1933).

[4] J. A. Martz, "Potash-Soda-Lime Feldspar Eutectic Study," *Jour. Amer. Ceram. Soc.*, **16** [7] 299–304 (1933).

[5] J. F. Schairer and N. L. Bowen "Preliminary Report on Equilibrium Relations between Feldspathoids, Alkali Feldspars, and Silica," *Geophys. Lab. Rept.*, No. 881 (1935); *Trans. Amer. Geophys. Union* (16th Ann. Meeting), **15**, 325–28 (1935).

[6] F. P. Hall and Herbert Insley, "A Compilation of

found no flint-feldspar eutectics, but they report that 20% quartz can be added to a potash feldspar and 10% to a soda feldspar without materially raising the melting points. A 50 to 50 mixture of flint and soda feldspar deforms a cone higher than the corresponding potash-feldspar mixture. Parmelee and McVay[8] also failed to find any evidence of a flint-feldspar eutectic.

Many efforts have been made to determine the solubility of quartz and clay in feldspar with rather discordant results. This subject is summarized by Parmelee and Amberg.[9] In their own work, mixtures were heated to temperatures up to 1475°C, and the cold melts were examined microscopically. The solution of both quartz and clay begins at a slightly lower temperature in soda feldspar than in potash feldspar. Soda feldspar at 1425°C dissolves 32 parts of quartz per 100 of feldspar or, at the same temperature, 36 parts of clay. The corresponding solution of quartz in high potash feldspar is only 4 parts and of clay 20.5 parts. (The low solubility of quartz in potash feldspar is not in agreement with results of most investigators.) In porcelain bodies the solution per 100 parts of feldspar is much higher, rising to 50 or 60 parts of quartz dissolved at 1425°. The authors state that "evidently the character of the solvent is something different from the pure feldspar."

(4) Feldspar in Bodies

It will be obviously impossible to review completely even the recent literature dealing with feldspar in bodies, and this account will seek only to recall data which have a beiarng on the present investigation.

The comprehensive investigation carried out at the Bureau of Standards was reported by Geller and Creamer.[10] A varied set of natural feldspars was submitted to a determination of fusion behavior and other properties. The same feldspars were introduced in equal amounts into typical vitreous and semivitreous bodies, which were compared as to firing behavior and properties of the finished product. For the present purpose, we are chiefly interested in the firing behavior of bodies made with the two end members of the series, pure high soda and high potash feldspars. Study of the data brings out two interesting facts, (1) with semivitreous bodies (containing no lime in the formula), the soda-feldspar body matured slightly ahead of the potash-feldspar body; (2) with the vitreous bodies (containing lime), the situation is exactly reversed, the high potash-feldspar body maturing ahead of the soda-feldspar body. These results in themselves are sufficient to discredit the idea that cone deformation of a feldspar is in any way an index of its efficiency as a flux in ceramic bodies.

With the coöperation of the Bureau of Standards, one of the present authors was enabled to check their results on vitreous bodies.[11] The earlier maturity of the potash-feldspar body was fully confirmed, and in addition it was observed that an equal mixture of potash and soda feldspar yielded a body which differed only imperceptibly in firing behavior from the straight potash-feldspar body. It was pointed out that in substituting feldspars any free quartz should be counted as flint in the formula and replacements made on the basis of actual feldspar content.

It has been suggested that variation in the properties of feldspars was due to difference in the soda-lime ratio, but Amberg[12] concludes, from examination of a large number of commercial potash feldspars, that the soda-lime ratio of the plagioclase constituent is practically constant at about 5.25.

Knight[13] describes the commercial feldspars of the United States and Canada and discusses the advantages of blending to maintain definite chemical composition. Potash feldspars of identical composition from different sources give the same results.

Parmelee and McVay[8] conclude that with some types of bodies the properties depend on the orthoclase-plagioclase ratio of the feldspar and that these tend to show optima with intermediate values of this ratio. Examination of their data, however, fails to yield very convincing evidence of this theory. The same authors determined the temperature of initial plastic flow under torsional stress of several electrical porcelain bodies. This proved surprisingly low, the bodies with high potash feldspar yielding at 814°C and with high soda feldspar at 770°C, both temperatures being far below the fusion points of the feldspars. The work of Martz,[4] already referred to, was applied by Chilcote[14] to the study of porcelain bodies. It was found that the ternary eutectic, microcline 30, albite 60, and andesine 10, developed more glass than any other combination of feldspars.

(5) Microstructure of Bodies

Some excellent microphotographs showing the changes which occur in the feldspar grains during the firing of porcelain are given by Norton.[15] It is shown that "the crystalline texture of the bodies receiving a long-time, low-temperature firing shows more quartz solution and more mullite development than the bodies which have received a short-time, high-temperature firing. The first development of mullite crystals in vitrified ware takes place in the feldspar grains. These grains have not lost the pseudomorphic outline of the original feldspar grain. The mullite needles in the interior of the grains do not extend be-

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Phase-Rule Diagrams," *Jour. Amer. Ceram. Soc.*, 16 [10] 463–567 (1933); p. 557.

[7] C. R. Amberg and J. L. Gallup, "Melting Relations of Potash Feldspar, Soda Feldspar, and Flint Mixtures," *ibid.*, 14 [10] 733–38 (1931).

[8] C. W. Parmelee and T. N. McVay, "Investigation of the Properties of Some Feldspars," *Univ. Ill. Expt. Sta. Bull.*, No. 233 (Sept., 1931).

[9] C. W. Parmelee and C. R. Amberg, "Solubility of Quartz and Clay in Feldspar," *Jour. Amer. Ceram. Soc.*, 12 [11] 699–710 (1929).

[10] R. F. Geller and A. S. Creamer, "Investigation of Feldspar and Its Effect in Pottery Bodies," *ibid.*, 14 [1] 30–71 (1931).

[11] Edward Schramm, "Effect of Potash and Soda Feldspars in China Body," *ibid.*, 10 [12] 1005–1006 (1927).

[12] C. R. Amberg, "Relation of Soda-Lime Ratio to Blending of Feldspars," *ibid.*, 15 [2] 140–43 (1932).

[13] F. P. Knight, Jr., "Commercial Feldspars Produced in U.S.," *ibid.*, 13 [8] 532–39 (1930).

[14] J. A. Chilcote, "Influence of Composition of Feldspar Constituent on Properties of a Porcelain Body," *ibid.*, 17 [7] 203–204 (1934).

[15] C. L. Norton, Jr., "Influence of Time on Maturing Temperature of Whiteware Bodies," *ibid.*, 14 [3] 192–206 (1931).

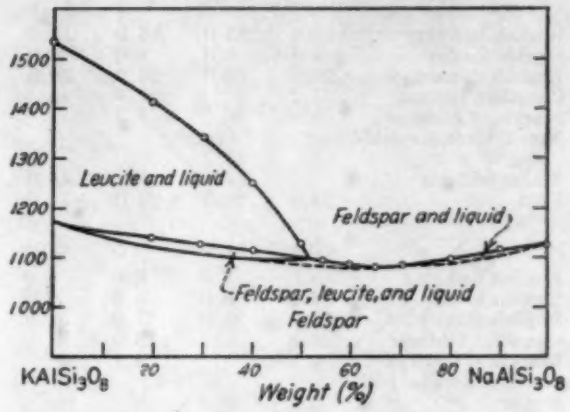

FIG. 1.—The alkali feldspar join in the ternary system $KAlSi_3O_8$–$NaAlSi_3O_8$–SiO_2 (circles indicate determined points). From J. F. Schairer and N. L. Bowen, *Trans. Amer. Geophys. Union*, 16th Annual Meeting, 1935.

yond this outline." To account for the mullite development, the author suggests that "some sort of slow diffusion goes on which makes the feldspar glass sufficiently rich in alumina so that mullite crystallizes out."

Parmelee and McVay[8] presented a series of photographs which are in agreement with Norton's results as indicated above.

(6) Direct Determination of Viscosity

The softening of feldspar glass was studied by Rieke and Mauve.[18] The method is the same in principle as that used in the hot-load testing of refractories. A small cylinder is deformed at constant temperature under constant load. The velocity of compression, *i.e.*, the time-deformation curve gives a measure of the viscosity. The apparatus consists of a platinum-wound tube furnace provided with suitable supporting and loading refractory rods and means for applying load and measuring the movement. The small cylinders used for the determinations are first sintered to incipient fusion. From the time-deformation curves, the dimensions of the specimen, and the applied load, viscosity can be calculated in absolute units.

The relationship between viscosity of potash-feldspar glass and temperature is approximately logarithmic between 1000° and 1200°C. Addition of silica increases the viscosity and more rapidly with larger quantities. Alumina up to 6% increases the viscosity, but larger amounts lower it. A small addition of lime sharply lowers the viscosity.

The relations with soda feldspar are quite different. The viscosity falls off more rapidly with rising temperature. The addition of CaO, BaO, MgO, and ZnO, in most cases, increases viscosity instead of lowering it as with a potash feldspar.

Determinations were also made on a mixture of 36.8% feldspar, 58.8% quartz, and 4.4% clay substance, taken to represent the composition of the glass phase in a hard porcelain. In these mixtures, the soda feldspar gave the least viscous melts, but the rapid softening with increased temperature, characteristic of the pure soda feldspar, does not occur. These mixtures gave a viscosity at 1200°, thirty times as great as that of the pure feldspar.

III. Plan of Investigation

It has often been pointed out that the glass phase is of controlling significance, both in the processing of whiteware and with respect to the final properties. Estimation of the quantity and quality of the glass should therefore afford a means of studying some of the questions connected with the use of feldspar, *e.g.*, the relative behavior of high potash, high soda, and intermediate feldspars and the validity of blending according to chemical analysis to produce material of fixed characteristics.

The porosity of a body fired to different temperatures gives directly a measure of the quantity of glass developed. The viscosity of the body at high temperature depends both on the quantity and nature of the glass; given a knowledge of the former through carefully carried out firing curves, the viscosity measurement affords considerable information as to the nature or quality of the glass. This is interesting since it affects the tendency of bodies to slump in firing. Owing to the striking influence of lime, the investigation included bodies with and without that element.

IV. Experimental

(1) Materials

Four feldspars were used in this investigation, a high potash and a high soda feldspar and two of intermediate type, all from different sources. The compositions are given as follows.

	Canadian	Maryland	Maine	N. C.
SiO_2	65.29	68.26	72.88	68.29
Al_2O_3	19.16	20.01	15.46	18.12
Fe_2O_3	0.05	0.04		0.08
CaO	0.40	0.69	0.60	0.32
K_2O	12.93	0.52	7.88	9.97
Na_2O	1.92	10.46	2.96	3.13
Ignition loss	0.17	0.28	0.22	0.15
	99.92	100.26	100.00	100.06
Ratio $\frac{\%\ K_2O}{\%\ Na_2O}$	6.75	0.05	2.66	3.18

A particle-size analysis of the feldspars was carried out by screening through a 325-mesh screen and submitting what passed to a sedimentation test. The results are grouped into three size ranges as follows:

[18] R. Rieke and L. Mauve, "Softening of Feldspar Glass and Influence of Different Additions Thereon," *Ber. deut. keram. Ges.*, **12** [8] 379–400 (1931); *Ceram. Abs.*, **11** [3] 188 (1932).

	Canadian	Maryland	Maine	N. C.
Over 16.6μ diam.	48.1	39.7	46.1	45.8
16.6–5μ diam.	27.3	31.2	26.4	28.0
Below 5μ diam.	24.6	29.1	27.5	26.2

These figures show good agreement in the grinding of the feldspars and provide assurance that the results obtained are not affected by any physical variable. Other materials used were identical in all of the prepared bodies.

(2) Bodies

To cover a wide range of application, three types of body were studied, *viz.*, semivitreous, SV, vitreous, V, vitreous containing lime, C. The base formulas were as follows:

	SV	V	C
English ball clay	15.0	15.0	8.0
Florida kaolin	8.0	8.0	6.0
English china clay	30.0	20.0	31.0
Feldspar	12.0	33.0	18.0
Flint	35.0	24.0	34.5
Whiting			2.5

In each series six bodies were prepared as follows:

(I) Formulas as above, using all Canadian high potash feldspar.

(II) Formulas as above, using all Maryland high soda feldspar.

(III) Formulas as above, using a combination of Canadian and Maryland to duplicate the potash-soda ratio of the North Carolina feldspar.

(IV) Using all North Carolina feldspar with above formulas modified to duplicate the chemical composition of III.

(V) Formulas as above, using Canadian and Maryland to duplicate the potash-soda ratio of the Maine feldspar.

(VI) Using all Maine feldspar with above formulas modified to duplicate the chemical composition of (V).

The actual compositions of bodies (III) to (VI) are given in the following tables:

	SV(III)	SV(IV)	SV(V)	SV(VI)
English ball clay	15.0	15.0	15.0	15.0
Florida kaolin	8.0	8.0	8.0	8.0
English china clay	30.0	30.0	30.0	30.0
Canadian feldspar	9.9		9.3	
Maryland feldspar	2.1		2.7	
North Carolina feldspar		13.0		
Maine feldspar				15.6
Flint	35.0	34.0	35.0	31.4

	V(III)	V(IV)	V(V)	V(VI)
English ball clay	15.0	15.0	15.0	15.0
Florida kaolin	8.0	8.0	8.0	8.0
English china clay	20.0	20.0	20.0	20.0
Canadian feldspar	27.2		25.5	
Maryland feldspar	5.8		7.5	
North Carolina feldspar		35.7		
Maine feldspar				43.0
Flint	24.0	21.3	24.0	14.0

	C(III)	C(IV)	C(V)	C(VI)
English ball clay	8.0	8.0	8.0	8.0
Florida kaolin	6.0	6.0	6.0	6.0
English china clay	31.0	31.0	31.0	31.0
Canadian feldspar	14.8		13.9	
Maryland feldspar	3.2		4.1	
North Carolina feldspar		19.5		
Maine feldspar				23.4
Whiting	2.5	2.5	2.5	2.5
Flint	34.5	33.0	34.5	29.1

V. Procedure

(1) Draw Trials

To follow the development of the bodies, small briquets were made up by pressing in plaster molds. These were fired along a standard curve with a temperature rise of 15°C per hour in the upper portion. The samples were drawn simultaneously. The porosity and bulk specific gravity were determined on small specimens after 4 days' immersion in water, all weighings being made on a sensitive chemical balance. The weighings for porosity determinations were carried out in a weighing bottle.

(2) Viscosity Determinations

The apparatus and procedure were essentially the same as that of Rieke and Mauve.[16] The load was applied to the specimen through a lever arm and deformations were observed with the aid of an Ames gage, sensitive to 0.0001 inch. The test cylinders were made by pressing cylindrical bars which, after drying, were sawed into sections which were brought true to dimensions by finishing in a brass ring. The specimens were $^7/_8$ inch in diameter and $^7/_8$ inch high.

The green specimen was placed in the furnace with a silicon-carbide cushion block to distribute the load and a silicon-carbide rod to transmit the load from a lever carried by a steel frame. The furnace was brought up along a standard curve to the desired temperature and held for an interval to allow the specimen to come to temperature; the load of 3.5 kilograms was then applied. With the furnace held constant from then on, readings of time and deformation were taken.

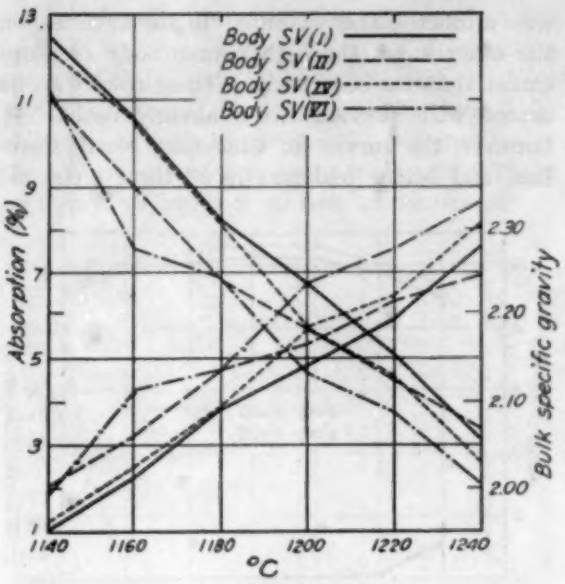

FIG. 2.

It will be noted that the test pieces were not prefired before the run. When the pieces are previously fired, higher viscosity values and, perhaps, better values of the true or equilibrium viscosity are obtained. The purpose in this work, however, was not to obtain theoretical data

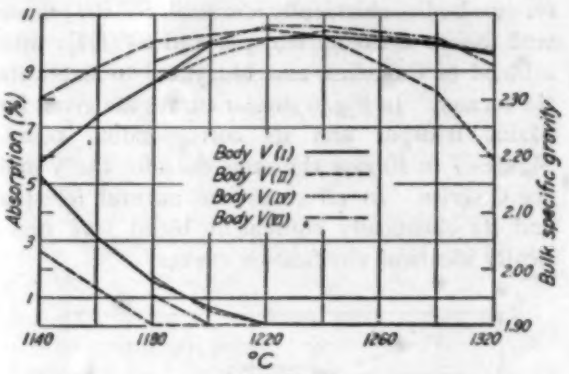

FIG. 3.

but information applicable to the normal procedure in firing ceramic bodies.

(3) Kiln Deformation Trials

Since the viscosity firings were of short duration as compared to actual practice, some confirmatory deformation tests were carried out in a commercial kiln. For this purpose small bowls of varying thickness with a flat bottom were cast and fired in the kiln inverted on a shrinking bat with a concentrated load of 75 grams in the center. The measured slump of the bottom was plotted against the bottom thickness to afford a basis for comparing the different bodies.

Kiln trials were also carried out in the following manner: Small hollow cylinders were made by core-casting, the approximate dimensions be-

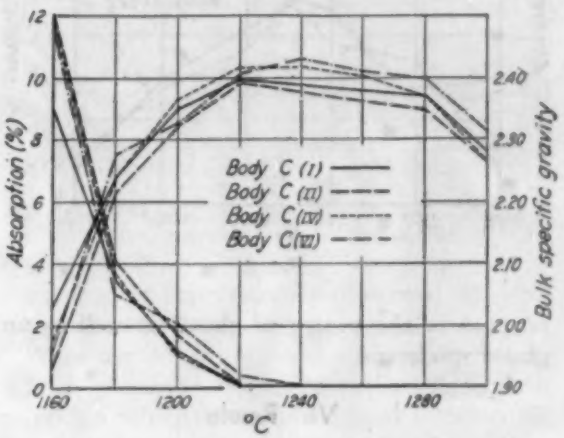

FIG. 4.

ing 2 inches in diameter, 1 inch high, and $^1/_4$ inch in wall thickness. These were fired, resting on the side, so that they came out slightly elliptical. The difference between the horizontal and vertical diameters gave an index of distortion in the kiln and therefore of viscosity of the bodies, since other variables were eliminated. This method is

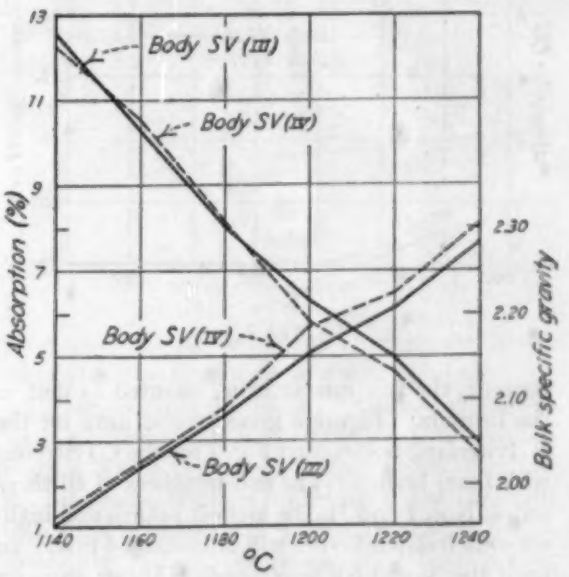

FIG. 5.

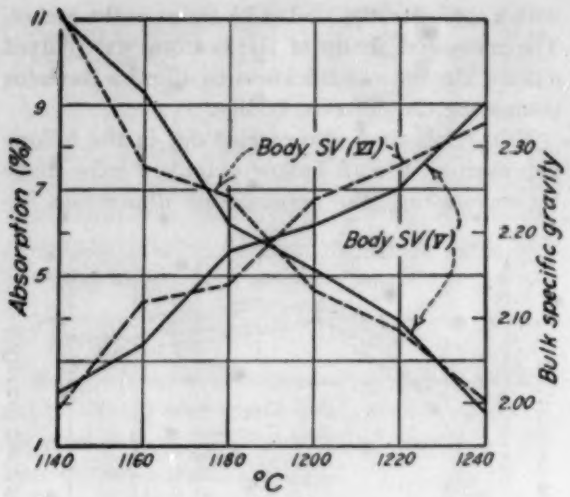

FIG. 6.

adapted to the testing of glazed as well as unglazed specimens.

VI. Results

The results are presented in the form of a series of curves. Figure 2 gives the data of the drawtrial firing on semivitreous bodies for the four bodies made from the unblended natural feldspars. It may be recalled that these bodies were compounded on the basis of equal actual feldspar

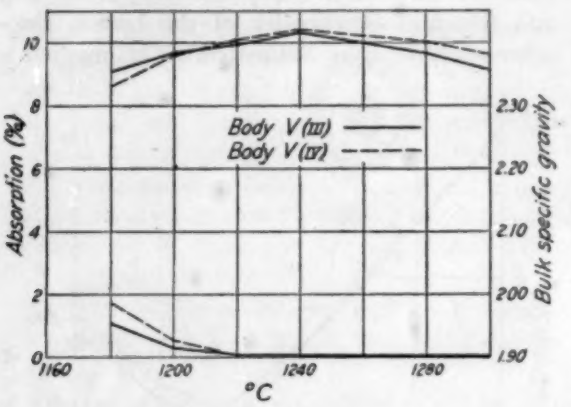

FIG. 7.

content, the free quartz being counted as flint in the formula. Figure 3 gives similar data for the V (vitreous) bodies, and Fig. 4 for the C (vitreous with lime) bodies. The end members of all three series, Nos. I and II, the highest potash and highest soda feldspar bodies will be discussed first. In both the V and SV series, soda feldspar gives an earlier development than potash feldspar and likewise a much earlier overfire. In the C series, on the other hand, the high potash body develops earlier than the soda body. These results are in accord with previous work already noted. If, however, the curves for Canadian, North Carolina, and Maine feldspars in all three series are

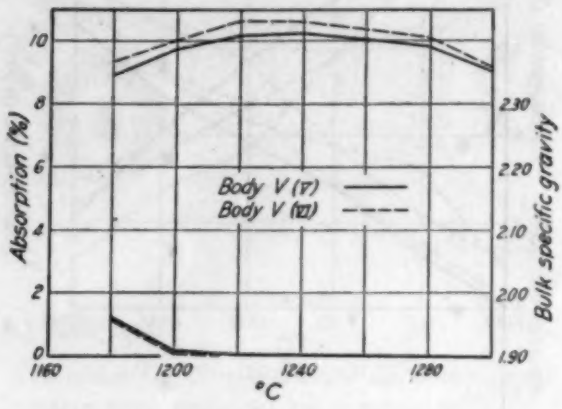

FIG. 8.

compared, the differences are negligible. A moderate soda content has no perceptible effect on the course of vitrification produced by a feldspar of the potash type.

In Fig. 5 are plotted the vitrification curves for two bodies chemically identical, SV (IV) made with North Carolina feldspar and SV(III), with a blend of Canadian and Maryland to duplicate the former. In Fig. 6 similar curves are given for Maine feldspar and its corresponding blend. Figures 7 to 10 give the same data for the V and the C series. In all cases the natural feldspar and its chemically equivalent blend give practically identical vitrification curves.

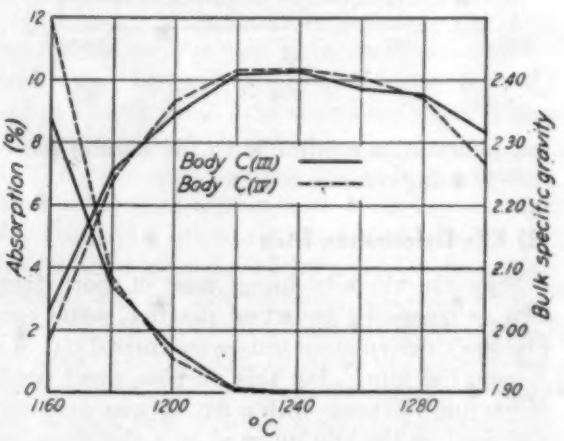

FIG. 9.

The viscosity data are also presented in the form of curves. Figure 11 gives deformation curves of all (I) and (II) bodies at 1300°C. This shows the general relationship of the three series of bodies at high temperature. Deformation of the SV bodies was so low that it was not thought necessary to attempt further measurements in

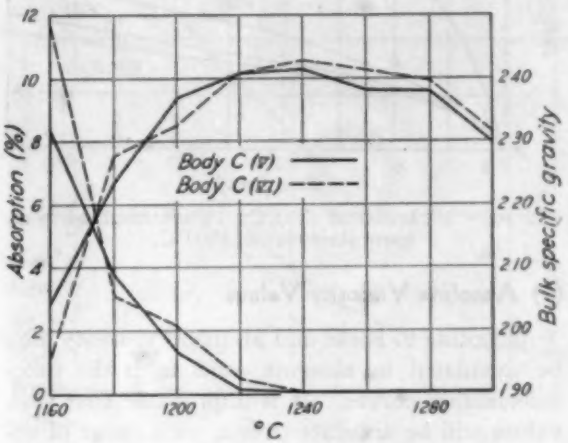

FIG. 10.

that series. Deformation of the C bodies was so rapid that it was decided to carry on further high-temperature work in that series at 1280°C. For the V bodies, 1300°C was retained as the point for high-temperature studies; in addition, both the C and V series were investigated at 1250°C,

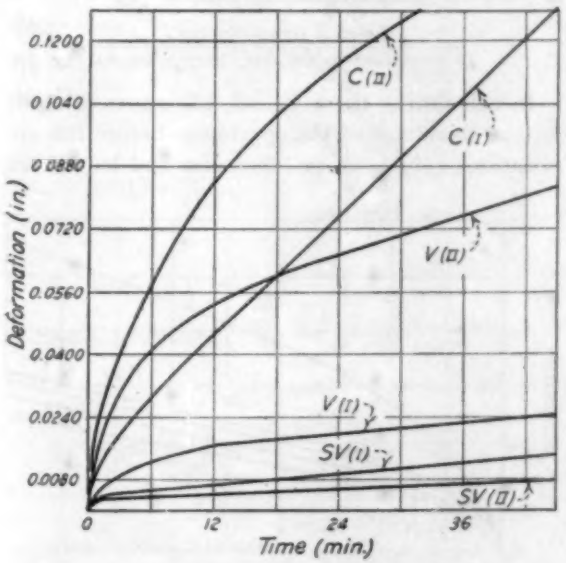

FIG. 11.—Deformation with load at constant temperature; curves show relative differences between the potash and soda feldspar bodies at 1300°C.

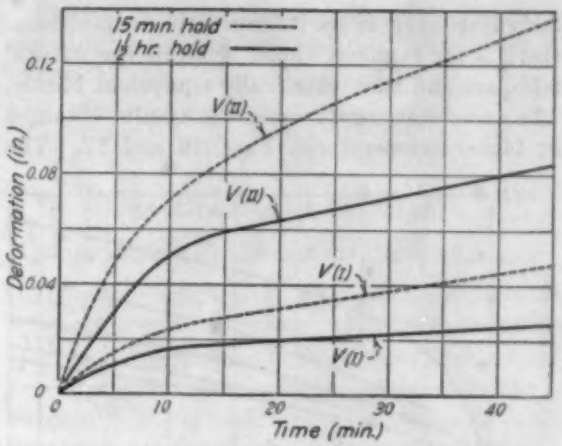

FIG. 12.—"V" bodies at 1300°C; effect of time of hold at 1300°C previous to application of load.

corresponding approximately to normal maturing temperature of the bodies.

When working at the lower temperatures a long hold is required to permit the completion of shrinkage before the load is applied. But at the higher temperatures, the bodies tend to stiffen when held for a prolonged time. This effect is illustrated by Figs. 12 and 13, giving deformation curves for four bodies with load applied after 15 minutes and after a 90-minute hold at high tem-

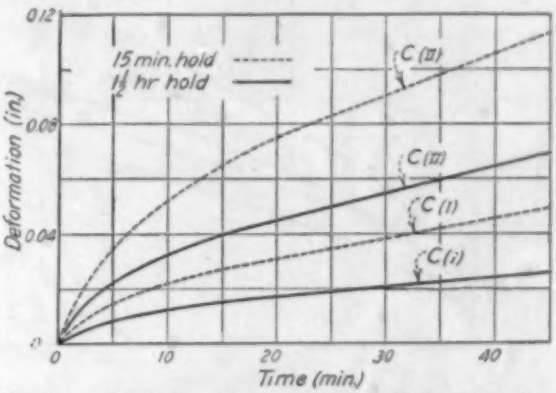

FIG. 13.—"C" bodies at 1280°C; effect of time of hold at 1280°C previous to application of load.

perature. In the later high-temperature determinations, the 15-minute hold was adopted.

Figure 14 gives the 1250°C deformation curves for the V series and Fig. 15 for the C series. In no case was a pronounced deformation obtained at this temperature in 45 minutes, the standard time for the load test. The soda-feldspar bodies show the highest deformation in both series; there is no indication that the highest potash

body is superior to the intermediate compositions; there is an excellent check between the natural feldspars and their chemically equivalent blends. The same statements cover the results obtained at higher temperatures, Figs. 16 and 17. The

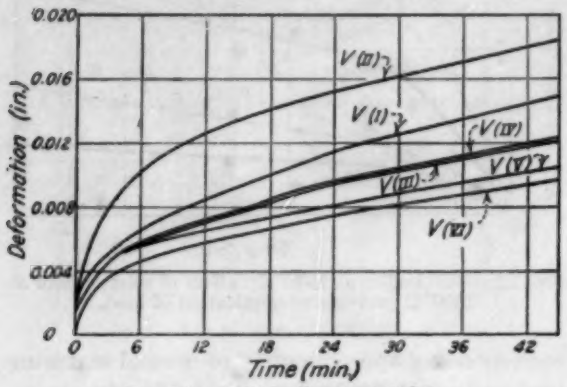

FIG. 14.—"V" bodies at 1250°C.

higher potash bodies, including the blends, are grouped close together and show much less deformation than the Maryland soda-feldspar bodies.

Figure 18 gives the slump-thickness curves obtained by firing bodies V (I) and V (VI) and C (I) and C (VI) in a commercial kiln. The slump-

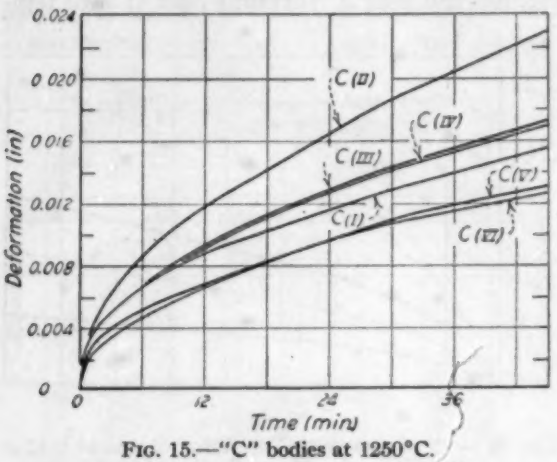

FIG. 15.—"C" bodies at 1250°C.

ing characteristics of these two pairs of bodies are identical, although the potash-soda percentage ratios of the feldspars used are 6.75 and 2.66.

The results of the cylinder deformation tests in a commercial kiln are given in the following table:

Body	Ellipticity Horizontal–vertical diameter (in.)
V(I) unglazed	0.084
V(I) glazed	.118
V(VI) unglazed	.074
V(VI) glazed	.108

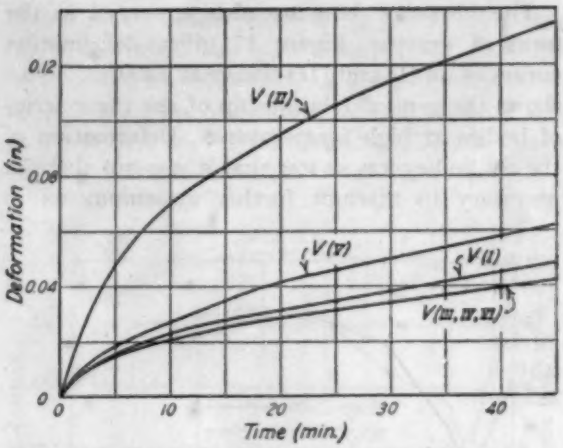

FIG. 16.—"V" bodies at 1300°C; 15 minutes hold to remove shrinkage at 1300°C.

(1) Absolute Viscosity Values

According to Rieke and Mauve,[16] viscosity may be calculated in absolute units from the time-deformation curves. It is improbable that such values will be accurate over a wide range of experimental conditions, but they are of the right order of magnitude and are interesting as affording a basis of comparison with known viscosities of other substances. For this reason viscosity constants based on the present data are presented, although they are not essential to the purpose of this paper.

According to Rieke and Mauve,[16] the viscosity in poises is given by the expression,

$$\frac{\text{Load in dynes/sq. cm.}}{\text{Deformation in cm./cm. length/second}}.$$

In calculating these values, allowance is made for the shrinkage of the specimens before the application of the load, *i.e.*, diameter and length are

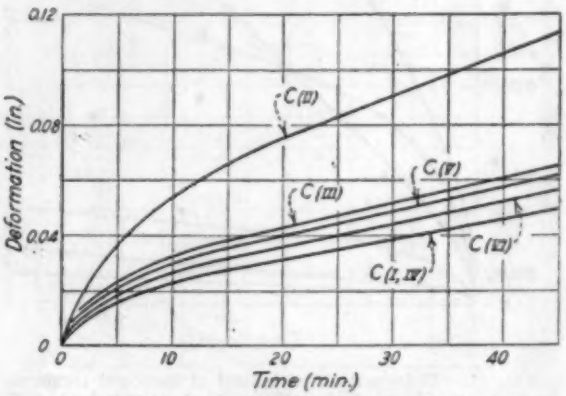

FIG. 17.—"C" bodies at 1280°C; 15 minutes hold to remove shrinkage at 1280°C.

0.77 inch or 1.95 centimeters. The load applied was 3.5 kilograms, more than twice that used by Rieke and Mauve in their work on feldspars.

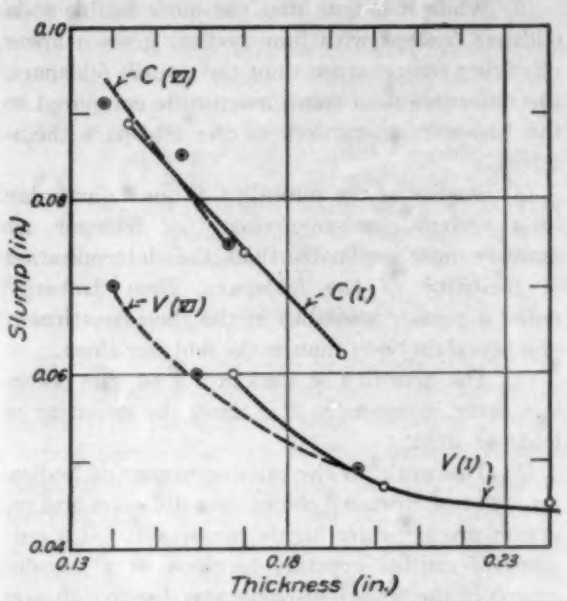

FIG. 18.—Inverted bowl loaded with weight of 75 grams and fired to 1240°C on shrink bat.

Nevertheless, it will be interesting to compare the viscosity figures for bodies with some of the data of Rieke and Mauve.

Bowen[17] gives data for viscosity of feldspars obtained by a different method. His results are as follows:

Albite	1150°C	10^8
Albite	1400°C	4×10^8
Orthoclase	1250°C	10^8

VII. Discussion and Conclusions

(1) High Potash and High Soda Feldspars

It is apparent, in agreement with earlier work (Geller and Creamer, *et al.*),[10] that high soda feldspar produces earlier vitrification in bodies without lime, but that in the presence of relatively small amounts of lime, the potash-feldspar bodies develop earlier than the soda bodies. The explanation of this (applying the findings of Martz[4] and of Rieke and Mauve[16]) is that lime causes a sharp increase in fusibility of potash feldspar but not of soda feldspar. It will develop in later discussion that the conception of the action of feldspar as a simple melting process is untenable; it is true, nevertheless, that greater fusibility promotes the activity of the feldspar and accounts for the difference in behavior of the two types of feldspar with and without lime. Even in the case where

[17] N. L. Bowen, "Viscosity Data for Silica Melts," *Trans. Amer. Geophys. Union*, No. 255 (1934).

VISCOSITY IN POISES

Body		Feldspar	Temp. (°C)	Time held (min.)	Viscosity ($\eta \times 10^{-8}$)
Semivitreous	SV(I)	Can. high potash	1300	90	19.8
	SV(II)	Md. high soda	"	"	29.4
Vitreous	V(I)	Can. high potash	"	"	9.9
	V(I)	" " "	"	15	5.0
	V(II)	Md. high soda	"	90	2.9
	V(II)	" " "	"	15	1.8
Vitreous lime	C(I)	Can. high potash	"	90	2.0
	C(II)	Md. high soda	"	"	1.3
	C(I)	Can. high potash	1280	"	8.5
	C(I)	" " "	"	15	5.2
	C(II)	Md. high soda	"	90	3.1
	C(II)	" " "	"	15	2.1
Vitreous	V(I)	Can. high potash	1250	90	15.3
	V(II)	Md. high soda	"	"	12.8
Vitreous lime	C(I)	Can. high potash	"	"	15.3
	C(II)	Md. high soda	"	"	10.3

FROM RIEKE AND MAUVE

Fused potash feldspar	with 10% quartz	1195	0.025
	" 25% "	"	0.026
	" 40% "	"	0.075
	" 60% "	"	0.106
		"	1.042
Fused potash feldspar	with 3% alumina	"	0.028
	" 6% "	"	0.050
	" 10% "	"	0.021
36.8 potash feldspar, 58.8 quartz, 4.4 kaolin		"	0.683
36.8 soda feldspar, 58.8 quartz, 4.4 kaolin		"	0.155

the vitrification with soda feldspar is later than with potash feldspar, the glass produced with the former is less viscous and soda bodies deform more readily. This, of course, is well known, and soda feldspars are never used alone as body materials.

(2) Potash Feldspars of Variable Potash-Soda Ratio

Of much greater practical interest is the question of the relative performance of different feldspars of the potash type. When used as previously described, such feldspars appear equivalent and interchangeable, giving similar vitrification curves and bodies of closely similar viscosity, both in laboratory determinations and practical kiln trials. A clue to this phenomenon may be found in the work of Schairer and Bowen (Fig. 1). The development of leucite crystals in melting, which accounts for the high viscosity of molten feldspar, persists almost undiminished with considerable admixture of albite to orthoclase.

(3) Chemical Control of Feldspars

The results obtained lend full support to the validity of chemical control. Certainly the mixtures of ground microcline and ground albite, represented by the blends of Canadian and Maryland feldspar, are not physically or mineralogically identical with the Maine or North Carolina feldspars they were intended to duplicate. In the natural intermediate feldspars, there are solid solutions of one feldspar in the other and perthitic intergrowth of these solutions. Such structures are not resolved by the grinding process. It is therefore apparent that these mineralogical differences are without significance in the use of feldspar as a ceramic flux.

(4) Discrepancy between Fusibility of Feldspar and Vitrification of Bodies

Much of the confusion with respect to feldspar may be traced to the tacit assumption that the action of the feldspar in the body could be predicted from the properties of the feldspar alone. That such an assumption is false is apparent from a number of considerations:

(1) The cone deformations of the feldspars used in this investigation are cone 5 for the Maryland, cone 8 for the Maine and North Carolina, cone 10 for the Canadian; yet larger quantities of the cone 8 feldspars are required than of the less fusible cone 10 material.

(2) While it is true that the more fusible soda feldspar (except with lime bodies) gives a lower vitrifying temperature than the potash feldspars, the difference is of small magnitude compared to the fusion temperatures of the feldspars themselves.

(3) Studies of the solubility of quartz and clay in a system consisting chiefly of feldspar are scarcely more applicable than the determination of fusibility of the feldspar. Thus Amberg[12] noted a greater solubility in the glass constituent of a porcelain body than in the feldspar alone.

(4) The quantity of glass in a fired true porcelain body is normally $2^1/_2$ times the quantity of feldspar used.

(5) The work on the microstructure of bodies, *e.g.*, that of Norton[15] shows that diffusion and reaction processes are highly important. If a network of mullite crystals develops as a pseudomorph of the large feldspar grains due to diffusion of alumina into the melting feldspar, it is apparent that an outward diffusion must occur at the same time, increasing the zone of glass formation beyond the boundaries of the original feldspar grains. A simple solvent action could not account for the phenomenon.

The various observations are best understood if the feldspar is regarded simply as the source of the fluxing elements needed for the formation of glass by reaction in the body. It is only one of the materials involved in this reaction, and it is no more reasonable to consider it by itself than would be a similar attempt to consider only the soda ash in studying the formation of ordinary glass. This viewpoint does not mean that fusibility is without significance, since it is one of the factors accelerating reactions, but it is not the only factor and often not the controlling one.

Acknowledgment

The authors are indebted to Stuart Schatz for carrying out many of the viscosity measurements reported in this paper, and to B. C. Burgess, United Feldspar Corporation, and H. B. DuBois, Consolidated Feldspar Corporation, for preparing and supplying the materials used.

Onondaga Pottery Company
Syracuse, N. Y.

I. THE MICROBIOLOGY OF AGING CLAYS*

By Dudley P. Glick

Abstract

The literature pertaining to microörganisms in clay and the aging of clay is reviewed.

Preliminary to attempting to determine the effect of microörganisms upon the aging of clay, six clay bodies have been examined and the numbers and kinds of microörganisms have been determined. The numbers of bacteria found, the variety of species, and their growth upon a medium prepared from an extract of ball clay are indicative of their activity. The bacteria identified are typical soil and water organisms. A method has been devised for the examination of the interior of lumps of native clay. One such clay gave no evidence of harboring living organisms beneath its surface, whereas the surface was highly contaminated, probably from external sources.

I. Introduction

At least seven different hypotheses have been advanced in an effort to explain the changes in plasticity in clays arising from the aging process. One of these is known as the bacterial theory. None of the forces suggested, however, seems to have been proved responsible for the changes in plasticity. The most generally accepted view appears to be that the various factors tend to contribute to the aging process as a group rather than as individual forces. This is supported in part by the present investigations.

These investigations were proposed to determine the relation, if any exists, between the biological activity which obtains in moist clay mixtures and the characteristics that facilitate their industrial use.

In stiff clay bodies, the aging process effects characteristics that are desirable, such as increased workability, improved texture, and increased bonding strength.

(1) Literature Review of Processes Involved

In the ceramic industry the clays intended for use in fine ware are stored in aging cellars or bins for periods of time varying from a few weeks to a year.[1]

When placing a freshly mixed clay body into the aging cellar, or upon establishing a new cellar, it is the practice of some ceramic workers to inoculate the new material with small amounts of well-aged bodies.[2]

Lafar[2] also states that German potters have been known to add manure-water to the storage heap to hasten and improve the aging process.

Watts[3] has reported that an aqueous extract of tan-bark tends to accelerate the aging process and[4] that the best conditions for aging clay are a temperature of 80°F and a relative humidity of 90%.

These reports are suggestive of the importance of biological activity but, to our knowledge, no one has determined the means whereby the various treatments bring about the observed changes within the clay.

Grimsley and Grout[5] suggest that, since bacteria are known to exist in clays, they may add organic colloids (protoplasm) to it, thereby increasing its plasticity.

Clays vary widely in their native plasticity and in the degree to which the plasticity or workability can be improved. The least plastic are the flints, feldspars, and primary kaolins; the most plastic are the ball clays, of which there are many commonly known to the ceramic industry. It is noteworthy that while those clays with the least plasticity contain little or no organic matter, the ball clays contain as much as 6% organic matter, being "... often dark gray in color and sometimes black from the association with vegetation in shallow, swamp-like lakes."[6]

One attempt, with which the writer is familiar, to solve the problem of bacterial activity in clay bodies would seem to present significant information, although the work was discontinued when barely under way, owing to lack of appreciation of its importance and to lack of bacteriological information both in fundamental principle and in technique.

Stover,[7] a New Jersey ceramist, sterilized a clay mixture and found that upon aging no change in the work-

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* Taken from a thesis, "The Mycoflora of Some Industrial Clays," presented to the Graduate School, Ohio State University, in partial fulfillment of the requirements for the degree of Master of Arts, 1932.

Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (White Wares Division). Received March 2, 1936.

[1] Alfred B. Searle, The Chemistry and Physics of Clays and Other Ceramic Materials. Ernest Benn, Ltd., London, 1924.

[2] Franz Lafar, Handbuch der Technischen Mykologie, Vol. 3, p. 465. Gustav Fischer, Jena, 1904–1907.

[3] A. S. Watts, "Egyptianized Clay" (discussion), *Trans. Amer. Ceram. Soc.*, **6**, 52 (1904).

[4] A. S. Watts, "Factory Preparation and Firing of Whiteware Bodies," *N. J. Ceramist*, **1** [2] 93 (1921); *Ceram. Abs.*, **1** [12] 320 (1922).

[5] G. R. Grimsley and F. F. Grout, *W. Va. Geol. Surv.*, **3**, 47 (1906); from H. Ries, Clays—Occurrence, Properties, and Uses, 3d ed. John Wiley and Sons, N. Y.

[6] Hewitt Wilson, Ceramics, Clay Technology, pp. 97–100. McGraw-Hill Book Co., Inc., New York, 1927; see also Searle, footnote 1.

[7] E. C. Stover, "Bacterial Growth as a Factor in Aging Clay Mixtures," *Trans. Amer. Ceram. Soc.*, **4**, 183 (1902); *ibid.*, **5**, 358 (1903).

ability of the mass could be observed; that is, it remained "short," whereas a similar mixture, not sterilized, increased in workability over a like period of time. Stover further observed that the addition of mineral acid (sulfuric acid) to the sterile mixture in no way increased its workability. It was found, however, that the addition of a small amount of the unsterilized, plastic mixture to the sterile body resulted in a pronounced increase in the workability of the latter after a period of two weeks.

Stover enlisted the services of two Philadelphia physicians who, with the aid of their microscope, demonstrated, much to the amazement of the local members of the American Ceramic Society, that bacteria existed not only in the clay body but in the water used in the preparation of the body as well. These workers reported the organism as *Bacterium sulphureum*. This name, unfortunately, is without significance today. Stover's work, however abortive, may well be considered a classic in the field of ceramic microbiology.

Acheson[8] has reported that the use of catechu, straw, or tannic acid tends to increase the workability of clay bodies.

Spurrier,[9] working upon clay bodies, reported as follows: (1) Evolution of carbon dioxide was found to continue for over thirty-four days after pugging and, like the change of plasticity, to proceed more rapidly between 80° and 90°F than below 60°F. (2) The effect of replacing water by non-aqueous liquids was to inhibit the development of plasticity altogether. (3) The effect of adding a dilute solution of hydrogen peroxide was to produce a pronounced increase of viscosity and also to stimulate the growth of algal filaments and the consequent evolution of both carbon monoxide and carbon dioxide.

Spurrier believes it probable, therefore, that the change of plasticity of clays with time is due, in some way, to the growth of such algae.

Wahlin[10] made the following observations: (1) Enamel slip is not sterile, as evinced by the isolation of two different microörganisms from a sample. (2) One of these organisms is capable of producing gas in the enamel slip by decomposing nitrates present. (3) A strong alkaline reaction is necessary for growth and denitrification by the organism. (4) Metallic ions exert an influence on the rate of denitrification, but they are accessory rather than indispensable to the process as well as to the growth of the cell. (5) There is no symbiotic relationship between the two organisms studied.

II. Microbiological Investigation

Samples of clay mixtures[11] were collected in glass tubes, 150 by 15 millimeters, that had previously been plugged with cotton and sterilized in steam at 15 pounds pressure. These tubes were filled by allowing slip to flow into them or by cutting a plug of clay from a stiff body in a boring fashion. When filled, the ends of the tubes were closed with corks to prevent moisture loss.

Sample No. 1 represents a natural slip and No. 2 a prepared slip[12]; No. 3 represents a standard tile body and No. 4 a prepared casting slip.[13]

All samples were treated alike as to quantitative and qualitative investigation.

(1) Sample No. 1

The p_H of sample No. 1 was 7.8.

The slip was examined primarily under the 16- and the 1.9-millimeter objectives of the microscope, the preparations being moist, unstained; moist, stained; fixed, unstained; and fixed, stained.

Under the oil-immersion lens bacteria were observed, occurring singly with occasional pairs. The majority of the organisms were bacilli; a few cocci were observed. There appeared to be no long chains of bacteria, no filaments of mold mycelium, and no algal cells. No protozoan forms were observed.

One cubic centimeter of the slip was removed with a sterile pipet, and the following dilutions were prepared in sterile water blanks: 1:10, 1:100, 1:1000, 1:10,000, 1:100,000, and 1:1,000,000. (*a*) One cubic centimeter of each dilution was plated in Difco brand beef-extract agar. The plates were incubated at 20°C ± 2°C. (*b*) One cubic centimeter of each dilution was added to tubes of potato extract-citric acid agar and plated for molds and yeasts. These were placed in the 20°C incubator. (*c*) One cubic centimeter of each dilution was plated in kaolin-extract agar[14] and incubated at 20°C. (*d*) One cubic centimeter of each dilution was plated in ball clay-extract agar[14] and incubated at 20°C.

In anticipation of a prolonged incubation period, the petri plates containing the clay-extract media were sealed with rubber bands to prevent moisture loss.

Following a four-day incubation period, ten different colonies were isolated from the beef-extract agar plates, and each was inoculated onto three agar slants of the same medium. One set

[8] E. G. Acheson, "Egyptianized Clay," *Trans. Amer. Ceram. Soc.*, **6**, 31 (1904); see also L. H. Minton, "Tests of the Acheson Process," *ibid.*, p. 231.

[9] H. Spurrier, "The Why of Aging Clay," *Jour. Amer. Ceram. Soc.*, **4**, 113 (1921).

[10] J. G. Wahlin, "Bacterial Growth in Enamel Slip," *ibid.*, **7** [3] 160–62 (1924).

[11] Samples from the Weller Pottery Co., Plant No. 3, and the Mosaic Tile Co., both of Zanesville, Ohio.

[12] From the Weller Pottery Company.

[13] From the Mosaic Tile Company.

[14] S. A. Waksman, Principles of Soil Microbiology, p. 15. The Williams and Wilkins Co., Baltimore, 1927.

of cultures was incubated at 20°C, another at 30°C, and the third set at 37°C. At the end of a four-day incubation period, the amount of growth was observed to determine the optimum temperature for carrying out further cultivation, although it was realized that individual cultures might present exceptions. From the observations it was concluded that 30°C would be the most satisfactory incubation temperature.

Following a fourteen-day incubation at 20°C, the beef extract-agar plates (*a*) showed an average count of 3,300,000 per cubic centimeter of slip. It must be borne in mind in dealing with a mixed flora such as is found in clay that the plate count does not reveal the total number of bacteria present, inasmuch as many organisms will not grow on the medium employed and those colonies that do appear may arise, not from a single organism, but from a microscopic colony in the clay.

Under similar incubation conditions, the mold plates (*b*) developed an average count of 3000. Plate No. 1 (1:10) contained 130 yeast colonies. None appeared on plates further in the series.

Following an incubation period of eight weeks, no growth appeared on the kaolin extract-agar (*c*).

Following an incubation period of four weeks, the ball clay-extract agar medium (*d*) showed an average plate count of 1500 bacteria and 100 molds. No increase in the plate count was observed at the end of eight weeks. All of the cultures isolated from the ball clay-extract plates were found to grow readily on beef extract-agar slants incubated at 30°C.

To secure anaerobic growth, one cubic centimeter of each dilution was inoculated into deep, dextrose-nutrient agar shake tubes that were flamed to reduce the oxygen tension and sealed with rubber stoppers. In addition, one cubic centimeter of each dilution was inoculated into tubes of the same medium, the contents of which were then drawn into sterile Vignal tubes that were subsequently sealed with a blast lamp. Further anaerobic culture was secured by preparing dilution plates with the dextrose-nutrient agar and the ball clay extract-media in separate series. The plates were inverted and one gram of pyrogallic acid was carefully introduced into each inverted lid and followed by 10 cubic centimeters of 10% aqueous potassium hydroxide. The plates were sealed immediately with molten paraffin.

The anaerobic cultures were incubated for two weeks at 30°C. At this time the dextrose-nutrient agar cultures showed an average plate count of 250,000, and the ball clay extract-agar cultures showed an average plate count of 800.

One hundred of the anaerobic cultures were isolated and reinoculated into deep, dextrose-nutrient agar shake tubes for anaerobic subculture and onto nutrient agar slants that were incubated aerobically at 30°C. All of the cultures grew readily under aerobic conditions, none appearing to be obligately anaerobic.

One hundred colonies were isolated from the nutrient agar plates and inoculated onto nutrient agar slants and incubated for four days at 30°C. At the end of the incubation period, these cultures were replated in three dilutions each to facilitate the securing of pure cultures. Those proving to be mixed cultures were re-isolated.

Each of the one hundred cultures was then inoculated onto three nutrient agar slants, incubated respectively at 20°C, 30°C, and 37°C, to determine which of the three temperatures would be optimum for further culture. After four days' incubation, each culture was inoculated into differential media and incubated for two weeks during which time observations were made daily and at the end of which the necessary chemical tests were made to characterize the cultures.

Bergey's Manual of Determinative Bacteriology[15] was employed in the identification of the bacterial cultures.

The following species of bacteria were isolated from this sample:

Achromobacter globiformis, Achromobacter hyalinum, Achromobacter iophagum, Achromobacter liquidum, Achromobacter reticularum, Actinomyces pheochromogenus, Bacillus adhaerens, Bacillus albus, Bacillus clostroides, Bacillus mesentericus, Bacillus prausnitzii, Bacillus subtilis, Flavobacterium aurantiacum, Micrococcus percitreus, Pseudomonas chlorinus, Pseudomonas rugosa, Rhodococcus corallinus, Serratia rosea, and one unidentified species.

The bacteria isolated are common to soil and water.

After the fourteen-day incubation period, the molds were isolated and inoculated onto large agar slants prepared from the potato extract-

[15] David H. Bergey, Manual of Determinative Bacteriology. The Williams and Wilkins Co., Baltimore, 1925.

citric acid medium and incubated at 30°C until spore formation occurred. Slide cultures were then prepared from the spores of each mold, according to the method of Henrici[16] and incubated in moist chambers at 30°C. Observations were made daily for two weeks. The following molds were identified with the aid of keys presented by Henrici[16] and Waksman:[14] *Alternaria humicola, Aspergillus glaucus, Aspergillus nidulans, Aspergillus niger, Aspergillus sulphureus, Aspergillus terreus, Aspergillus wentii, Monilia sitophila, Mucor mucedo, Mucor plasmaticus, Rhizopus arrhizus, Rhizopus nigricans, Oidium* sp., and *Trichoderma* sp.

The yeasts were *Saccharomyces* sp., according to Henrici.[16]

(2) Sample No. 2

This sample was treated in the same manner as sample No. 1 and its p_H was 7.6

On nutrient agar plates, incubated at 20°C for two weeks, the average bacteria count was 4 million.

On potato extract-citric acid agar plates, incubated at 20°C for two weeks, the average mold count was 225,000. No yeast colonies were observed.

The optimum temperature for ten cultures chosen at random was 30°C.

No growth appeared on kaolin extract agar after eight weeks' incubation at 20°C.

Following an incubation period of four weeks at 20°C, the ball clay extract medium showed an average count of 2400 bacteria and 70 molds. Although the colonies of bacteria and molds increased somewhat in size, there was no increase in the count at the end of eight weeks. All of the cultures isolated from this medium grew readily on nutrient agar slants incubated at 30°C.

The dextrose-nutrient agar anaerobic cultures showed an average count of 300,000.

The ball clay extract-agar anaerobic cultures showed an average count of 700.

All of the anaerobic colonies grew well on nutrient agar slants, incubated aerobically at 30°C.

Subsequent to the isolation of one hundred cultures, the following species were identified:

Achromobacter hyalinum, Achromobacter liquidum, Achromobacter reticularum, Bacillus circulans, Bacillus clostroides, Pseudomonas rugosa, and *Serratia rosea.* There were also two unidentified species.

Employing the technique described above, the following molds were identified: *Aspergillus glaucus, Aspergillus nidulans, Aspergillus niger, Aspergillus sulphureus, Aspergillus terreus, Monilia sitophila, Mucor mucedo, Rhizopus nigricans, Oidium* sp., and *Trichoderma* sp.

(3) Sample No. 3

Sample No. 3 was investigated in the same way as sample No. 1 and its p_H was 7.6.

Microscopic examination of this sample demonstrated the presence of bacilli, which occurred singly, in pairs, and in small, unorganized groups.

On nutrient agar plates incubated aerobically for two weeks at 20°C, the average bacteria count was 24 million.

On the potato extract-citric acid agar plates, incubated aerobically for two weeks' at 20°C, the average mold count was 700. No yeast colonies were observed.

A study of the temperature relationships of ten colonies isolated at random indicated that 30°C would be optimum.

No growth was evident on the kaolin extract agar plates after eight weeks' incubation at 20°C.

After four weeks' incubation at 20°C, sample No. 3 exhibited a bacteria count of 3100 and a mold count of 30 on the ball clay-extract agar. There was no increase in the count after eight weeks. All of the organisms isolated from this medium grew well on nutrient agar slants at 30°C.

The dextrose-nutrient agar anaerobic cultures showed an average count of 150,000. The ball clay extract-agar anaerobic cultures showed an average count of 400. All of the colonies isolated from these media grew well on nutrient agar slants, incubated aerobically at 30°C.

The following species of bacteria were identified: *Achromobacter filifaciens, Achromobacter geniculatum, Achromobacter liquidum, Bacillus flavus, Bacillus fluorescens, Bacillus fusiformis, Bacillus mycoides, Bacillus subtilis, Flavobacterium aurescens, Flavobacterium brevis,* and *Pseudomonas rugosa.*

Molds were isolated as described above. Only three different species were identified. These were *Aspergillus glaucus, Aspergillus niger,* and *Rhizopus nigricans.* No yeasts were observed.

[16] A. T. Henrici, Molds, Yeasts and Actinomyces, p. 33. John Wiley and Sons, New York, 1930.

(4) Sample No. 4

The p_H of sample No. 4 was 8.0. It was held in the original sample tube for three months. During this time the average temperature of the laboratory was 30°C. At the end of this period the p_H of the sample was 7.4; it was then investigated in the manner described above.

The nutrient agar plates, incubated aerobically for two weeks at 20°C, developed a bacteria count of 381 million.

On the potato extract-citric acid agar plates, incubated aerobically at 20°C for two weeks, there appeared only two colonies, one in the 1:10 dilution and one in the 1:100 dilution.

The optimum temperature of ten colonies isolated at random was found to be 30°C.

No growth appeared on the kaolin extract agar, incubated at 20°C, at the end of eight weeks.

Following four weeks' incubation at 20°C, the ball clay extract medium showed an average bacteria count of 3500. No molds were observed. No increase in count was observed at the end of eight weeks. All of the cultures isolated from this medium grew well on nutrient agar slants incubated aerobically at 30°C.

The dextrose-nutrient agar anaerobic cultures showed an average count of 520,000, and the ball clay extract-agar anaerobic cultures showed an average count of 800. All of the anaerobic cultures grew well on nutrient agar slants, incubated aerobically at 30°C.

The following species of bacteria were isolated from this sample: *Achromobacter album*, *Bacillus adhaerens*, *Bacillus flavus*, *Bacillus megatherium*, *Bacillus mycoides*, *Bacillus pseudotetanicus*, *Bacillus subtilis*, and *Pseudomonas viscosa*.

Subsequently, two more slips were examined. These had been held in storage at the plant for five to six months and differed thus from the clay mixtures described above as well as in composition.

(5) Sample No. 5

Sample No. 5 represents a biscuit slip containing sodium silicate. The examination was carried out as described above. The p_H of this sample was 8.0.

On nutrient agar plates, incubated at 30°C for two weeks, the average bacteria count was 4,800,000.

On the potato extract-citric acid agar plates, incubated at 30°C, neither mold nor yeast colonies appeared at the end of four weeks.

No growth appeared on the kaolin extract-agar plates, incubated at 30°C for four weeks.

The ball clay extract-agar plates, incubated at 30°C for four weeks, showed an average count of 750 bacteria with no molds. All of the cultures isolated from this medium grew well on nutrient agar slants, incubated at 30°C.

The dextrose-nutrient agar anaerobic plates showed an average count of 300,000. Cultures isolated from these colonies grew well on nutrient agar slants, incubated aerobically at 30°C.

The following bacterial species were isolated from this sample: *Achromobacter dacunhae*, *Achromobacter sulfureum*, *Actinomyces olivaceus*, *Actinomyces poölensis*, *Serratia rosea* (this organism comprised about 20% of the colonies), two unidentified species of *Achromobacter*, and two unidentified species of *Flavobacterium*.

(6) Sample No. 6

The p_H of this sample was 7.4. It represents a vitreous slip without sodium silicate and was originally prepared at a temperature approximating 55°C. This sample was examined in the manner described above.

On nutrient agar plates, incubated for two weeks at 30°C, the average bacteria count was 10,500 billion.

On potato extract-citric acid agar plates, incubated at 30°C for four weeks, neither mold nor yeast colonies appeared.

No growth appeared on the kaolin extract-agar at the end of four weeks' incubation at 30°C.

At the end of four weeks' incubation at 30°C, the ball clay extract-agar plates showed an average count of 1900 bacteria and no molds. All cultures isolated from these plates grew well on nutrient agar slants, incubated at 30°C.

The dextrose-nutrient agar anaerobic plates showed an average count of 400 million. All cultures isolated from these colonies grew well on nutrient agar slants, incubated aerobically at 30°C.

Only three different species were isolated from this sample. The approximate proportion of the total number of colonies represented by each species accompanies the name, *Achromobacter dendriticus* (20%), *Achromobacter globiformis* (60%), *Flavobacterium ovalis* (20%).

III. Bacteriological Examination of Small Lumps of Clay

Small lumps of unwashed Kentucky ball clay were examined to determine what microörganisms, if any, existed within the native material. This clay was quite dry, being representative of the material as received for industrial use.

To examine the interior of these lumps without contamination from the surface, it was necessary to sterilize the surface of each lump examined. This was accomplished by exposure to iodine vapor. A 250-cubic centimeter wide-mouth bottle was fitted with a cork stopper. The stopper was fitted with a cradle of copper wire small enough to enter the mouth of the bottle with ease. Iron wire was avoided because of the affinity between iron and iodine. The cradle was made to accommodate lumps of clay of about 2 centimeters mean diameter in such a way as to support the lump securely and at the same time to permit the removal of the lump to a sterile petri dish by forcepts to avoid contamination. About five grams of crystalline iodine were placed into the bottle.

To ascertain the effectiveness and utility of this method, the following procedure was carried out: Lumps of clay were exposed, individually, to the iodine vapor, at a temperature of about 30°C, for 0.5, 1, 3, 5, 10, 15, 20, 25, and 30 minutes. These were then placed into sterile petri dishes and a tube of nutrient agar, melted and cooled, was poured over each lump, which was then removed from the dish with sterile forceps. The removal was made necessary owing to the slaking of the clay in the aqueous medium. When solid, the agar plates were incubated at 30°C for two days. It was found that an exposure of thirty minutes sterilized the surface of the lumps.

The penetration of the iodine vapor was followed in a similar series of exposures by breaking open the lumps and observing the depth of iodine coloration. This was checked by painting the freshly exposed surface with starch solution.

To demonstrate that any bacteria which might exist within the clay lumps would not be killed by the action of the iodine vapor upon the surface, a lump of clay was prepared by drilling a small hole to its center. Into this cavity was introduced a portion of a culture *Bacillus subtilis*, in the vegetative stage, and the cavity was sealed with paraffin. The lump was exposed to iodine vapor for thirty minutes, placed into a sterile petri dish, and broken with sterile forceps. The bacteria grew readily.

It is of interest that, up to and including the five-minute exposure, molds predominated on the plates prepared to test the effectiveness of the iodine vapor, whereas upon longer exposure the number of mold colonies relative to the number of bacterial colonies diminished rapidly.

Both the nutrient agar medium and the clay extract medium were employed in examining the interior of the clay lumps. Upon exposing the lumps to iodine vapor for thirty minutes and then breaking them open in sterile petri dishes, adding the medium and incubating, no living bacteria were found to exist.

IV. Summary

Six samples of industrial clay mixtures were examined quantitatively and qualitatively for bacteria, molds, and yeasts.

Large numbers of bacteria were found to be present in each sample.

A considerable variety of bacteria was found to obtain in samples of recently prepared clay mixtures which were examined soon after their being obtained.

In a sample held in the laboratory for three months before examination, spore-forming bacteria predominated. Since this sample was not examined soon after it was secured, this observation is not offered as evidence that other types of bacteria, that might have been present earlier, had died.

Samples taken from tanks containing clay mixtures that had been stored for five or six months were characterized by a reduced number of species, an increased number of bacteria, and the absence of molds and yeasts.

The bacteria isolated and identified were aerobic or facultative as were those whose habitat is known to be soil or water. No obligate anaerobes were observed. Several cultures could not be identified with any species already described.

The optimum temperature of the majority of the bacteria isolated was found to be 30°C. Exceptions were noted.

A medium prepared from an aqueous extract of a ball clay was found to support bacterial growth, whereas a medium prepared from an aqueous extract of a primary kaolin was found not to support bacterial growth.

All of the organisms isolated from the ball clay medium were found to grow readily on a beef extract-agar (nutrient agar) medium.

A method was devised for the bacteriological examination of small lumps of native clay without fear of contamination by surface organisms. Application of this method to an unwashed, Kentucky ball clay indicated that living organisms were to be found only upon the surface.

Acknowledgments

The author wishes to express his appreciation for the advice and assistance rendered by the following: G. A. Bole, Department of Ceramic Engineering, Charles B. Morrey, Professor Emeritus of Bacteriology, George E. Helz, Department of Physiological Chemistry, formerly of the Department of Bacteriology, all of the Ohio State University; C. D. Ford of the Mosaic Tile Co., of Zanesville, Ohio; and the Weller Pottery Co., of Zanesville, Ohio.

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DATA ON THE INFLUENCE OF FIRING TIME ON THE PROPERTIES OF SOME WHITEWARE BODIES*

BY ARTHUR S. WATTS

ABSTRACT

Data have been obtained by firing a variety of whiteware bodies in commercial kilns to a given pyrometric cone deformation at different rates of temperature increase, indicating that the faster rate of firing gives lower water absorption and greater firing shrinkage.

I. Introduction

From various studies of the process of vitrification, the writer concluded many years ago that this problem may be divided into two parts, *viz.*, (*a*) the superheating of the glassy phase beyond its softening temperature, by which its viscosity is reduced and its pyrochemical activity accelerated, and (*b*) the progressive solution of the remainder of the body or at least such portions of it as are soluble in the glassy phase. The glassy phase may consist of a combination of body constituents which unite as a eutectic or may be a single mineral as a feldspar. Either of these, if heated above its initial softening temperature in the absence of other material, will decrease in viscosity in proportion to the increase of temperature. If alumina or silica or both are dissolved in excess of eutectic proportions, the glassy phase will increase in viscosity unless the temperature increase is sufficient to offset the influence of the added alumina and silica.

The decrease in viscosity of the glassy phase is essentially a matter of temperature, the factor of time being only involved in the rate of heat penetration from the surface to the interior of the mass.

The progress of solution of other body constituents by the glassy phase is, however, a process in which time plays a definite part, due (1) to the speed of reaction and (2) to the increasing degree of saturation which progressively retards the rate of solution.

An important physical factor in the progress of solution is the dissemination of the glassy phase throughout the mass. If it is of such fine grain that homogeneity is approached, the amount of time and the decrease of viscosity necessary to permit the glassy phase to envelop every grain of other material is greatly reduced, as indicated by the action of extremely fine-grained feldspar.

II. Processes of Vitrification

Vitrification can therefore be accomplished by any of the three processes following:

(1) By a rapid temperature increase, whereby the glassy phase reaches the required degree of fluidity with the minimum amount of solution of associated material, followed by a short soaking treatment for the solution of the associated material.

(2) By a gradual temperature increase, whereby the glassy phase is at all stages relatively saturated with associated material, requiring an increased final temperature to provide the required degree of fluidity of the glassy phase for complete dissemination throughout the mass, and followed by a short or moderate soaking period for the solution of associated material.

* Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 31, 1936 (White Wares Division).

(3) By a gradual temperature increase, whereby the glassy phase is at all stages relatively saturated with associated material as in process (2) but halting at the temperature attained in process (1) so that the glassy phase never reaches the degree of fluidity attained in process (1), and following this by a prolonged soaking treatment made necessary by the reduced activity of the more viscous glassy phase.

In none of these processes is overfiring involved. If the glassy phase becomes too fluid, the ware will distort. If the rate of temperature rise is too gradual, the glassy phase unless greatly superheated, never reaches a satisfactory state of fluidity for ideal dissemination and the ware has a stony bond not productive of translucency.

Evidence supporting the foregoing philosophy has come to the writer's attention from time to time, but the data were never sufficiently complete to challenge the age-old theory that "the more gradual the rate of temperature increase, the lower the temperature necessary for a definite degree of vitrification."

The writer's first conclusive evidence was in the research conducted by Durbin and Watts.[1] These data indicated that, with the body employed, a definite increase in shrinkage and modulus of rupture and a proportionate decrease in absorption was produced when cone 9^8 was reached in 35 hours with 3 hours' soaking and 32 hours' cooling, as compared with the same cone deformation reached in 70 hours, with 7 hours' soaking and 63 hours' cooling. These data were not accepted for publication by the Editorial Committee of the White Wares Division. As further evidence of the accuracy of the observations previously reported, the following data are submitted.

[1] E. A. Durbin and A. S. Watts, "Study of the Effect of Grain Size of Some Feldspars on the Properties of a Standard Whiteware Body." Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio (February, 1934).

TABLE I

Bodies	A (%)	B (%)	C (%)	D (%)	E (%)
Body feldspar	19.3	18.2	17.1	15.9	14.7
American ball clay	15.0	15.0	15.0	15.0	15.0
American china clay	25.2	26.9	28.6	30.3	32.0
Flint	40.5	39.9	39.3	38.8	38.3

These five bodies were prepared in quantity and formed into bars, 1 by 1 by 7 inches, by a carefully standardized procedure. At least 25 standard bars of each body were fired in each of two tunnel kilns on the following schedules: kiln No. 1: 39 hours to cone 10^5, 4 hours' soak, 33 hours' cooling, total 76 hours; and kiln No. 2: 50 hours to cone 10^5, 8 hours' soak, 50 hours' cooling, total 108 hours.

Both are direct-fired tunnel kilns fired with natural gas.

TABLE II

Body	Firing shrinkage (%) 76 hr.	108 hr.	Modulus of rupture (lb.) 76 hr.	108 hr.	Absorption (%) 76 hr.	108 hr.
A	7.40	7.20	7067	6792	2.43	3.13
B	7.35	6.93	6975	6617	3.03	4.10
C	6.98	6.78	6770	6250	3.90	4.78
D	6.63	6.40	6590	6300	5.00	5.93
E	6.30	6.08	6750	6120	6.20	7.15

NOTE: The data on the values for the individual bars were remarkably uniform and none was rejected in the calculation of averages.

Conclusions

With these five bodies, the firing shrinkage and the modulus of rupture are greater and the absorption less in every case where the more rapid firing rate is employed.

The evidence so far presented represents processes 1 and 3 only. Evidence on process 2 can not be practically developed with the industrial kilns available, although the writer hopes to be able to present data on this process at a later date.

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KINETICS OF SOME REACTIONS OF INTEREST TO CERAMISTS*

The Disintegration of Blast-Furnace Linings Due to Carbon Deposition†

By C. C. Furnas

Abstract

The reaction has a maximum rate between 450°C and 500°C. Experimental work showed that commercial fire brick could be completely shattered by the reaction in a few hours. Firing brick in reducing atmosphere reduces the rate of deposition.

I. Introduction

(1) Statement of the Case

The linings of blast furnaces have frequently shown the distressing characteristic of disintegrating in the lower temperature region of the wall while the furnace is in service.

Examination of various linings that have been disintegrated shows that disintegration usually begins just above the mantle, in the outer half of the wall, and from there channels upward toward the top and gradually works in closer to the inner face of the wall. In the case of a wall where the disintegration has only begun, solid brick are found next to the inner face and next to the shell, but cracked and crumbled brick are found in the central portion of the wall.

Disintegration in the lining usually begins with the forming of large transverse cracks in the brick accompanied by gray discoloration and followed by a decided crumbling.

Although this trouble is usually found above the mantle, it has also been found in the bosh, usually starting close to the cooling plates.

It would seem that the phenomenon displays a preference for a certain temperature range and does not operate at a higher or a lower temperature.

In the beginning stages, the width of the channel of disintegration varies from a few inches to as much as two feet. As soon as the central portion of the wall begins to crumble, the brick of the inner face begin to loosen and fall away, thus diminishing the thickness of the lining, and as it becomes thinner, the region of favorable temperature for the disintegration creeps nearer and nearer the outer face until in a relatively short time all of the wall that is left is thoroughly disintegrated and soon wears away completely.

Disintegration seems to cut down the life of a lining to 50% or even less of what it would otherwise have been.

(2) Previous Investigations

In the years gone by, various explanations have been advanced to account for this disintegration. Some have said that it was a spalling due to temperature change and others have attributed the crumbling of the brick to the depositing of zinc which might be present in the ore. Investigators, however, have definitely established that the disintegration is due to the deposition of carbon according to the reaction

$$2CO = C + CO_2. \qquad (1)$$

Fundamental physical-chemical studies of this reaction by various investigators[1] have been made. The results show that this chemical reaction is possible and that carbon monoxide will decompose to give carbon and carbon dioxide. Several investigators[2] have experimentally dis-

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† Two other examples of reactions of interest in ceramics were presented by the author, but, having been previously published, they are not included in this paper. They are (1) "Rate of Calcination of Limestone," *Ind. Eng. Chem.*, **23**, 531 (1931), and (2) "Rate of Reduction of Iron Ore with Carbon Monoxide," *ibid.*, **26**, 983 (1934).

[1] (*a*) E. Audibert and A. Raineau, "Action of Iron Catalysts on Mixtures of Carbon Monoxide and Hydrogen," *Ann. combustibles liquides*, **3**, 367–428 (1928).

(*b*) V. Falcke and W. Fischer, "Equilibrium between Carbon Monoxide, Carbon, and Carbon Dioxide, and the Reaction between Ferrous Oxide and between Carbon Monoxide and Iron," *Z. Elektrochem.*, **32**, 194–201 (1926).

(*c*) G. Meyer and F. E. C. Scheffer, "Dissociation of Carbon Monoxide," *Rec. trav. chim.*, **46**, 754–62 (1927).

(*d*) T. F. E. Rhead and R. V. Wheeler, "Effect of Temperature on the Equilibrium $2CO = CO_2 + C$," *Jour. Chem. Soc.* [London], **97**, 2178 (1910).

(*e*) Alfred Stansfield, "Equilibrium for the Reaction $2CO = CO_2 + C$," *Trans. Amer. Electrochem. Soc.*, **51**, 217–24 (1927).

(*f*) Hirosi Tutiva, "Catalytic Decomposition of Carbon Monoxide: I, Iron as Catalyst," *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **10**, 69–82 (1929).

[2] (*a*) E. Diepschlag and K. Feist, "Disintegration of Blast-Furnace Refractories by Carbon Monoxide," *Feuerfest*, **4** [9] 133–36 (1928); *Blast Furnace Steel Plant*, **17**, 280–82 (1929); *Ceram. Abs.*, **8** [3] 193 (1929).

(*b*) R. P. Heuer, Discussion on "Prevention of Disintegration of Blast-Furnace Linings," *Jour. Amer. Ceram. Soc.*, **12** [1] 30–31 (1929).

(*c*) H. K. Mitra and A. Silverman, "Prevention of Disintegration of Blast-Furnace Linings," *ibid.*, **11** [5] 278–91 (1928).

(*d*) C. E. Nesbit and M. L. Bell, "Firebrick Disintegration," *Brick Clay Rec.*, **62**, 1042–43 (1923); *Ceram. Abs.*, **2** [10] 223 (1923).

(*e*) B. M. O'Harra and W. J. Darby, "Disintegration of Refractory Brick by Carbon Monoxide, "*Jour. Amer. Ceram. Soc.*, **6** [8] 904–14 (1923).

(*f*) Bernhard Osann, "Experimental Proof of the Disintegration of Linings and Charges in the Blast Furnace by the Decomposition of Carbon," *Stahl & Eisen*, **27**, 1626–28 (1907).

integrated fire brick by keeping them in a chamber which contained carbon monoxide at a temperature from 400° to 600°C.

All the investigations have established the fact that the carbon monoxide will not decompose either inside of brick or outside unless a catalyst is present to promote or induce the reaction. Various investigators have not agreed on what the catalyst might be in certain fire brick which did promote this reaction. Hubbard and Rees[3] say that pure kaolin or pure silica will produce the reaction. Mitra and Silverman[2c] found that ferrous oxide (FeO) will catalyze the reaction, but that Fe_3O_4 is not a catalyst. O'Harra and Darby [2e] say that metallic iron must be present in order to catalyze the reaction. Osann[2f] found the same thing. Tutiva[2f] says that the catalyst must be iron carbide (Fe_3C).

Some investigators have suggested remedies for the situation which might prevent this troublesome disintegration of fire brick. Heuer[2b] says that if the iron which is contained in a fire brick can be reduced to FeO it will form a eutectic with alumina (Al_2O_3) and silica (SiO_2) at 1100° and that this material will not catalyze the deposition of carbon. Mitra and Silverman[2c] recommend that the ferric oxide (Fe_2O_3) be reduced to Fe_3O_4 in making the brick and thus prevent the deposition. Nesbit and Bell[2d] say that the only remedy is to allow the clay from which fire brick is made to weather and to separate the portion of clay which is discolored by iron, thus making a low-iron brick. If the findings of Hubbard and Rees[3] are true, namely, that the reaction is catalyzed by kaolin and silica, it would seem as if there were no remedy possible.

But obviously, from this summary of previous work, there is disagreement among investigators as to the cause and the remedy, so another contribution to the subject might not be amiss.

II. Summary of Analyses

The experimental work described below was conducted several years ago but has not been previously published.

A careful examination was made of the analyses of ninety-eight different specimens of brick, the samples including new, disintegrated, and used but solid brick.

From the analysis viewpoint all of the new brick were very much the same. There was as much variation between individuals of the same kind as between different kinds.

Individual, rather than group, variation seemed to hold in the comparison of brick which were able to withstand usage and those which were not. Zinc and alkali content averaged higher in the disintegrated samples, but individual variation was too large to draw any general conclusions.

In the matter of carbon content, however, it seemed safe to draw the conclusion that the percentage of this element nearly always ran higher in a disintegrated brick than in a solid one which had been used in a furnace.

The analyses fail to give any conclusive evidence of any kind.

III. Macroscopic Examination

Careful examination reveals that disintegration is always accompanied by localized deposits of carbon. These deposits are in the form of amorphous carbon and are in little spherical globules, usually about the size of a pea, but sometimes they are as much as three-quarters of an inch in diameter.

These carbon deposits are magnetic, proving the presence of iron or magnetic iron oxide or both. Analysis shows that the globules contain 70 to 90% carbon.

Large cracks always radiate from a carbon segregation as soon as it has arrived at reasonable size, and apparently it is here that the large cracks, which are characteristic of disintegration, start.

A careful study has been made of the conditions of a typical carbon deposit, and it has been calculated that this deposit, which formed a large crack in the brick, must have exerted a pressure of about 18,000 pounds per square inch to accomplish the result. This result was arrived at by assuming the tensile strength to be 100 pounds per square inch,* measuring the diameter of the carbon button and assuming it to be spherical, calculating its surface, then measuring the area of the surface exposed by the cracking of the brick, calculating how much force of compression must be exerted over the whole surface, and hence how much must be exerted on the whole surface of the carbon button.

A small volume of iron oxide tested in an atmosphere of carbon monoxide at 450° to 500°C will deposit a really large volume of carbon. Nesbit and Bell[2d] have made some quantitative determinations of this effect and have found that ferric oxide will deposit as much as 70 times its volume of carbon.

It would seem then that in the course of disin-

[3] D. W. Hubbard and W. J. Rees, "Dissociation of Carbon Monoxide in Contact with Refractory Materials," *Trans. Ceram. Soc.* [England], **28** [6] 277–307 (1929); *Ceram. Abs.*, **8** [11] 816 (1929).

* Upon the authority of Merriman's Mechanics of Materials.

TYPICAL ANALYSES OF THE VARIOUS BRICK

Type of brick (A)	Iron oxide (Fe_2O_3)	Silica	Alumina	Lime	Magnesia	Loss by ignition
Hearth and bosh	2.28	54.20	42.12	0.36	0.84	None
Inwall	1.43	54.04	43.23	0.44	0.93	None
Top	1.43	54.18	43.35	0.46	0.76	None
Type of brick (B)						
Hearth and bosh	1.85	56.12	40.89	0.38	0.81	0.06
Inwall	2.57	58.54	37.17	0.66	0.98	None
Top	2.28	58.90	36.80	0.34	1.04	0.13

AVERAGE ANALYSES OF NEW BRICK USED FOR BLAST-FURNACE LININGS

	No. Samples	Iron oxide (Fe_2O_3)	Silica	Alumina	Lime	Magnesia	Loss
A	12	3.01	54.06	41.44	0.56	0.98	0.05
B	4	2.25	58.25	37.94	0.50	0.91	0.05
C	6	1.76	56.48	40.32	0.53	0.90	0.01
Grand average	22	2.54	55.50	40.90	0.54	0.95	0.04

AVERAGE ANALYSES OF SOLID BRICK TAKEN FROM BLAST-FURNACE LININGS AFTER USE

	No. Samples	Iron oxide (Fe_2O_3)	Silica	Alumina	Lime	Magnesia	Loss	Carbon (20)*	Zinc (7)*	Alkalis (12)*
A	23	3.05	49.70	38.86	0.80	1.00	1.82	3.55	0.50	4.90
B	18	2.27	56.90	35.35	0.97	1.13	1.09	1.40	0.13	3.55
Not disintegrated	9	4.35	53.26	39.95	0.27	0.87	0.48	1.22	0.00	0.47
Grand average	50	3.00	52.75	36.91	0.76	1.02	1.32	2.17	0.18	3.02

* The numbers in parentheses indicate that the average is calculated from the result of that number of analyses instead of the number indicated at the end of the line.

AVERAGE ANALYSES OF DISINTEGRATED BRICK TAKEN FROM BLAST-FURNACE LININGS

	No. Samples	Iron oxide (Fe_2O_3)	Silica	Alumina	Lime	Magnesia	Carbon (18)*	Loss	Zinc (10)*	Alkalis (11)*
A	20	3.08	47.15	35.56	0.87	1.06	6.09 (2)	3.49	1.24 (2)	6.29 (2)
Not disintegrated	6	3.19	50.62	40.77	1.29	0.80	2.88	2.53	0.00	1.13
Grand average	26	3.10	47.90	36.80	0.97	0.98	(20) 5.78	3.27	(12) 1.30	(13) 5.57

* The numbers in parentheses indicate that the average is calculated from the results of that number of analyses instead of the number indicated at the end of the line.

tegration a great deal of carbon must result from the reaction,[1c]

$$2CO = CO_2 + C. \qquad (1)$$

A careful study of the equilibrium conditions and physical-chemical considerations of this reaction show that if a system of these three substances were in equilibrium, that is to say, in a stable state, at 450°C, there should be approximately only 3% of carbon monoxide in the gaseous phase. Hence, if an atmosphere of greater than 3% of carbon monoxide is at such a temperature, there is a tendency for it to decompose and deposit carbon. Further consideration of the energy relations of this reaction show that an atmosphere of pure carbon monoxide is in reality only approaching stability at temperatures above 1100°C. The question then may be immediately asked as to why an atmosphere of 20% or more of carbon monoxide gas remains as such at ordinary temperatures? The answer is that although the compound is unstable it remains in this state at ordinary conditions or if it does start to decompose it does so so slowly that the result is negligible for our considerations. A condition similar to this will be found in the case of ammonium nitrate. This compound is usually considered stable, whereas a study of the physical chemistry of the compound shows that it is very willing to decompose and will do so under the correct conditions. Recent explosions of this compound, of unparalleled violence, are sufficient evidence to prove the theory.

It would seem then that most of the carbon is deposited according to equation (1) but that there must be some agency to urge it on for it does not occur under ordinary conditions. Something in the nucleus started by the deposit of carbon by the oxide acts as a catalytic agent and causes the carbon monoxide to begin adjusting itself to equilibrium condition. It may be some peculiarity

FIG. 1.—Experimental disintegration of a type A hearth and bosh brick; 9 hours' exposure to 75% carbon monoxide at 470°C.

of the oxide present, or it may be that carbon once started to deposit forms a crystalline structure which tends to grow even against enormous pressure, just as a crystal of a salt in a supersaturated solution will grow very rapidly. In all events it seems almost certain that ferric oxide starts carbon depositing and that such carbon will deposit indefinitely even after it has burst the brick. The preference of solid carbon for localization after deposition has once started is shown by the fact that, in some of the tests which have been run, brick have been thoroughly disintegrated and have still remained white in color, whereas an adjacent brick under exactly the same conditions, and which we were not able to disintegrate, was colored a dark gray. In the second case there was no localization, but reaction (1) proceeded anyway and deposited carbon in very small particles all over and through the brick.

IV. Experimental Work

To test out the theories outlined above, several tests were run on the brick used in blast-furnace plants. The tests consisted of heating large pieces of the various brick in an atmosphere of carbon monoxide at temperatures between 450° and 500°C. The carbon monoxide was obtained by passing a stream of carbon dioxide, which was obtained from the action of hydrochloric acid on marble, over and through charcoal heated to 1000°C and above.

The various types of brick A were all disintegrated (types: top brick, 40% plastic, 60% flint; inwall 25% plastic, 75% flint; hearth and bosh, 15% plastic, 85% flint). Disintegration usually occurred within twelve hours. The gas used for the disintegration contained from 60 to 95% of carbon monoxide. The temperature ranged from 450° to 500°C as indicated above.

The first sample to be disintegrated was a type A brick. It was heated in an atmosphere of carbon monoxide for 41 hours. The average temperature was 450°C. The gas averaged 60% of carbon monoxide.

FIG. 2.—Disintegration products from a type A hearth and bosh brick, exposed to 80% carbon monoxide for 9½ hours at 480°C, compared with broken face of one-half of original brick.

The next sample to be disintegrated (sample No. 3) was a type A hearth and bosh brick. It was kept in atmosphere, averaging 75% carbon monoxide, at an average of 470°C for 9 hours. The sample was thoroughly disintegrated. Figure 1 shows its condition as it was taken from the testing furnace. The large localized carbon deposits are easily seen.

The next successful test was on another sample of type A hearth and bosh brick, sample No. 9. This sample was kept in an atmosphere, averaging 80% carbon monoxide, at an average temperature of 480°C for 9½ hours. The sample was thoroughly crumbled and shattered, as is shown in Fig. 2.

A cross-section of this original solid brick is shown in the center, the effective results of localized carbon being seen on either side of the solid piece. Note the large pieces of carbon in front of the solid piece. These were picked from the disintegrated portion.

FIG. 3.—First steps of disintegration. A type A brick exposed to 65% carbon monoxide for 6½ hours at 460°C.

Figure 3 illustrates the beginning of disintegration (sample No. 3B). This sample was kept in an atmosphere of 65% carbon monoxide at an average temperature of 460°C for 6½ hours. The segregations or buttons of carbon are easily seen in the large cracks which have begun to develop.

A type A top brick (sample No. 23) was disintegrated after an 11-hour exposure to an atmosphere containing 70% carbon monoxide at 450°C. No photograph was taken of this disintegration.

One sample of type C brick (No. 22) has been disintegrated after a 135-hour exposure to an atmosphere of 70% carbon monoxide.

V. Inadequacy of Theory

The type A brick were the only ones which disintegrated to any appreciable extent in service.

The disintegration tests which have been run have, as a rule, verified the lesser susceptibility of other makes of brick to disintegration. This is well illustrated by Fig. 4, which shows the pieces of a type B brick still intact after having been exposed to an atmosphere containing 50 to 80% CO at temperatures between 450° and 500°C for 97 hours. The brick was broken in pieces before being put into the test furnace.

It does not necessarily follow, however, that the other makes of brick are invulnerable. Figure 5 shows that it is possible to disintegrate these brick. Specimen (1) shows the disintegration resulting from exposing a type B inwall brick to an atmosphere containing 60 to 85% of CO at temperatures between 415° and 500°C for a period of 30 hours. . This is the best case of the disintegration of the type B brick which was observed. Slight disintegration, however, occurred in other cases. Specimen (2) of Fig. 5 shows the result of a 135-hour test on a type C top brick. The CO ran from 20 to 85%, the temperature, 425° to 500°C. Slight disintegration has occurred in the case of one other type C sample. In general then, it is evident that type A brick were easy to disintegrate; type B and C fire brick were difficult to disintegrate. The two clays for bricks A and B come from entirely different deposits. Type A clay lies in coal strata, while the type B occurs in sandstone formation. This, however, does not seem to cause the analysis of the clays to differ to a marked extent as will be shown by an

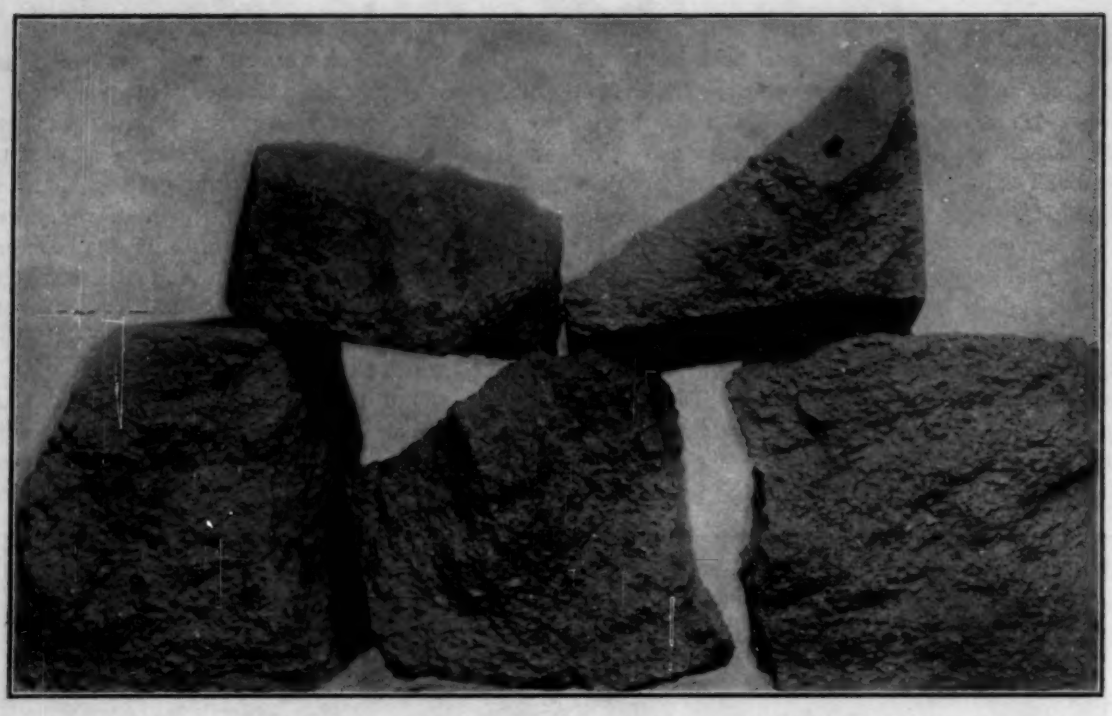

FIG. 4.—Pieces of a type B brick which failed to disintegrate in an atmosphere of 50 to 80% carbon monoxide at 450° to 500°C for 97 hours.

analysis of the clays which will be given later. Hence it would seem that the trouble lies elsewhere than in the clay deposit.

Since iron oxide is the important constituent in the phenomenon under consideration, especial attention was paid to this. Analysis of sample No. 1, a type A brick which disintegrated, gave an iron oxide content of 1.71%. Analysis of sample No. 2, a type B brick which did not disintegrate, gave an iron oxide content of 2.28%. Evidently then there must be some other factor in disintegration than the quantity of iron oxide.

This conclusion led to further consideration of the iron oxides in the brick. Careful examination showed that most of the iron oxide segregations in the type B brick, which usually do not disintegrate, were the magnetic oxide, while most of the segregations in the type A brick, which did disintegrate, were the nonmagnetic oxide, Fe_2O_3. This can be determined by means of a small magnetic pick, and some evidence can be gathered from the appearance.

Analyses show that usually the iron oxide content of the type A brick is very much the same as that of the type B. The size of oxide segregations in the two different kinds of brick seems to be about the same.

VI. Theory of Difference in Brick

The following theory then has been formulated to explain the difference in the actions of these two kinds of brick.

The brick are made from very much the same kind of clay, and in both cases the iron occurs in much the same form. The iron may occur in the clays in the form of any of its oxides, as iron pyrites (FeS_2) or as iron carbonate ($FeCO_3$).

In firing brick all of these various forms of iron tend to become Fe_2O_3, provided a good supply of air is kept up during the firing. FeS_2 decomposes to give Fe_2O_3 and SO_2. $FeCO_3$ decomposes to give CO_2 and FeO, which in turn is oxidized to Fe_2O_3. Very little, if any FeO occurs free in the clays. Analysis for this constituent failed to show more than a trace. Carbonaceous matter in brick stops oxidation of iron and may even reduce the iron present. If a strongly oxidizing atmosphere is not maintained in the kiln during firing the iron will end up in a partly reduced condition. In the drying and baking, the type B must have been subjected to a reducing treatment which produced the magnetic oxide (Fe_3O_4). The finished type B brick then contained this magnetic oxide which will not start a nucleus of carbon to burst the brick. The treatment for

type A brick must have been such that the oxide nearly all finally occurs as Fe_2O_3 and so is susceptible to disintegration.

VII. Difficulties of Proof

Experimental work was continued with the purpose of either proving or disproving the above theory. There were, however, a number of difficulties in the way.

Attempts were made to oxidize thoroughly the magnetic oxide in the type B brick so that it would be susceptible to disintegration, but the oxide is by nature very inert and after it is occluded and baked in the brick it seems to be very unwilling to oxidize, so disintegration by this method has not been attained.

Further attempts were made to reduce the ferric oxide of the type A brick to the magnetic oxide without the deposit of carbon and then to see if it would be possible to disintegrate the brick. These experiments were unsuccessful. This reduction, however, is difficult to accomplish because of inertness of the oxide and the required fineness of temperature adjustment.

These experiments then did not offer any proof for or against the theory.

VIII. Experimental Evidence for the Theory

Small amounts of ferric oxide and of magnetic oxide, heated at 450°C in an atmosphere of carbon monoxide and the ferric oxide, deposited a large amount of carbon while the magnetic oxide did not deposit any at all.

The results of the following tests are good evidence in favor of the theory.

A specimen of finely ground roll scale (Fe_3O_4) was placed in an atmosphere of oxygen at 1000°C for 24 hours and became nonmagnetic, apparently being oxidized to Fe_2O_3. This sample (type A) was placed alongside a sample (type B) of unoxidized roll scale (Fe_3O_4) and a sample (type C) of iron ore ($Fe_2O_3 \cdot xH_2O$). These samples were placed in an atmosphere of 75% carbon monoxide at 460°C for 9 hours.

Type A showed considerable carbon deposit; type B did not deposit any carbon; and type C deposited a large quantity of carbon.

The following tests afford more conclusive evidence for the theory:

Two pieces of type B brick, which would be unlikely to disintegrate, were carefully broken. Holes, $^9/_{16}$ inch in diameter and $^1/_2$ inch deep, were bored in the cleavage faces of each of the

FIG. 5.—Specimen (1): type B brick disintegrated with 60 to 85% carbon monoxide at 415° to 500°C for 30 hours. Specimen (2): type C brick disintegrated with 20 to 85% carbon monoxide at 425° to 500°C for 135 hours.

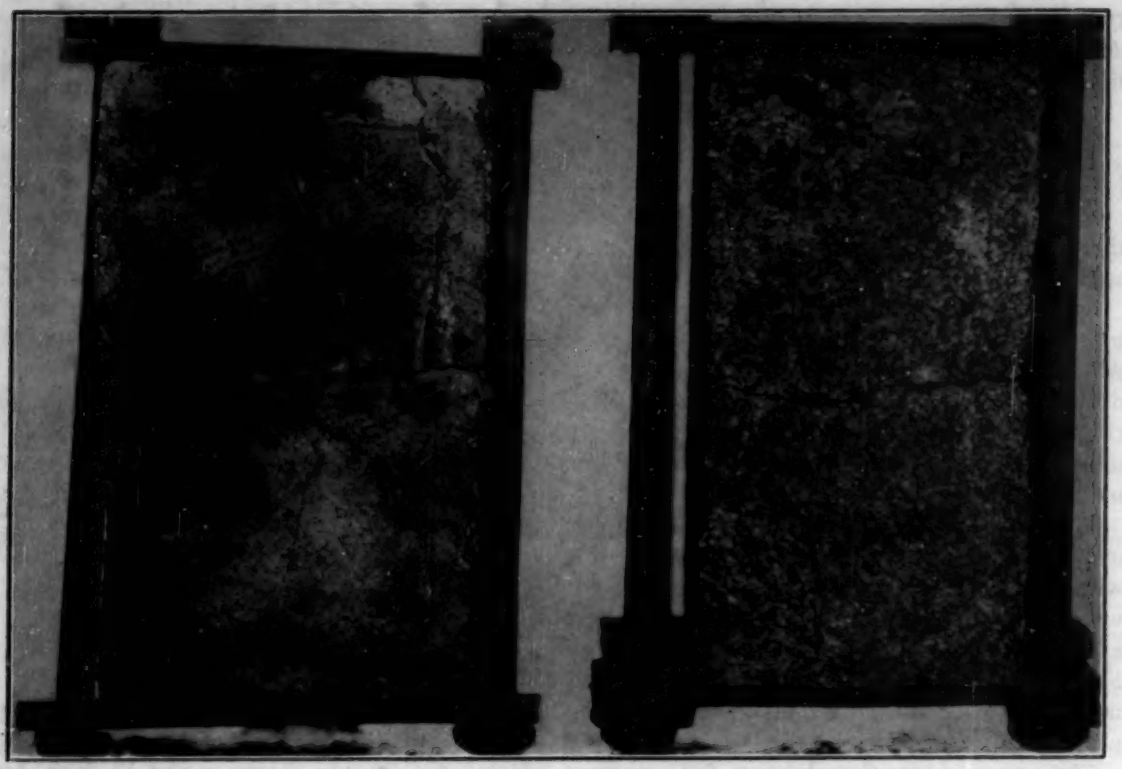

FIG. 6.—Result of exposure to disintegration to reducing conditions for 83 hours; specimen (1); iron ore placed between sections; specimen (2), roll scale placed between sections.

specimens. In one of these samples (No. 24), the holes were filled with the magnetic oxide (Fe_3O_4). In the other sample (No. 25), the holes were filled with Fe_2O_3. The pieces were firmly clamped into their original positions. The two samples were then subjected to disintegration conditions for 83 hours. At the end of that time, sample No. 25 had disintegrated, while No. 24 was unaffected. This is shown by Figure 6. Specimen (1) is sample No. 25, containing Fe_2O_3; specimen (2) is sample 24.

To make the evidence more conclusive it was decided to make some test brick.

Samples of plastic and flint clays were obtained from the companies manufacturing bricks A and B. The analyses of these clays were as follows:

	Iron oxide	Silica	Alumina	Lime	Magnesia	Sulfur	Carbon	Loss
Clay A								
Flint	0.57	43.90	41.29	0.14	0.43	0.016	0.13	13.68
Plastic	1.15	55.68	32.13	0.18	1.04	0.202	0.42	9.39
Clay B								
Flint	1.15	44.44	40.41	0.16	0.54	0.029	0.11	13.08
Plastic	1.44	54.24	33.57	0.28	0.78	0.040	0.25	9.59

The brick of each kind of clay were made of 75% flint and 25% plastic clay. They were 2 by 2 by 4 inches. This then made the iron oxide content of the type B brick 1.22% and of the type A brick 0.95%.

One-half of the brick were fired in an atmosphere of oxygen, the rest being fired in a reducing atmosphere of CO.

After firing, both sets of these brick were subjected to a disintegration test of 30 hours. No disintegration occurred. Figure 7 shows their final appearance. Specimen (1) is a brick made of type A clay, fired in an oxidizing atmosphere, specimen (2) is the same kind of a brick fired in a reducing atmosphere; specimen (3) shows a type B brick fired in an oxidizing atmosphere; specimen (4) is the same kind of a brick fired in a reducing atmosphere.

The results, then, of this test were disappointing, for no evidence of any kind was obtained. It was thought, however, that the reason for this lay in the fact that the samples of clay which were

FIG. 7.—Sample brick made up for tests.

sent to us were lower in iron content than the average clay taken from these districts. The amount of iron oxide in the test brick ran 1.22 and 0.95% for type B and type A, respectively, whereas an analysis of several brick manufactured by these two companies showed an average of 3.01% iron oxide for type A and 2.25% for type B.

Believing, therefore, that the clays were not representative, another lot of brick was made up from a dry mix of 75% flint and 25% plastic clays. Part of this was molded into brick similar to the first lot. To another part was added 2.5% of its own weight of iron ore, Fe_2O_3, ground to pass a 4-mesh sieve and to remain on an 8-mesh. To another portion was added 2.5% of its own weight of roll scale (Fe_3O_4) ground the same as above. These oxides were thoroughly mixed in and the clays were molded into brick, 2 by 2 by 4 inches.

The final content of iron oxide (Fe_2O_3) or its equivalent was as follows:

A with Fe_3O_4 added	3.44%
A with Fe_2O_3 added	3.37
B with Fe_3O_4 added	3.70
B with Fe_2O_3 added	3.63

These brick were then subjected to firing for a period of 96 hours. Part of each kind was fired in a reducing atmosphere of CO gas, part in the oxidizing atmosphere of a stream of air. The maximum temperature of the reducing atmosphere was 1350°C. The maximum temperature of the oxidizing atmosphere was 1325°C.

After the brick were made they were placed in the experimental furnace under disintegration conditions. According to the theory advanced, the brick fired in a reducing atmosphere, no matter which oxide was originally added, should not dis-

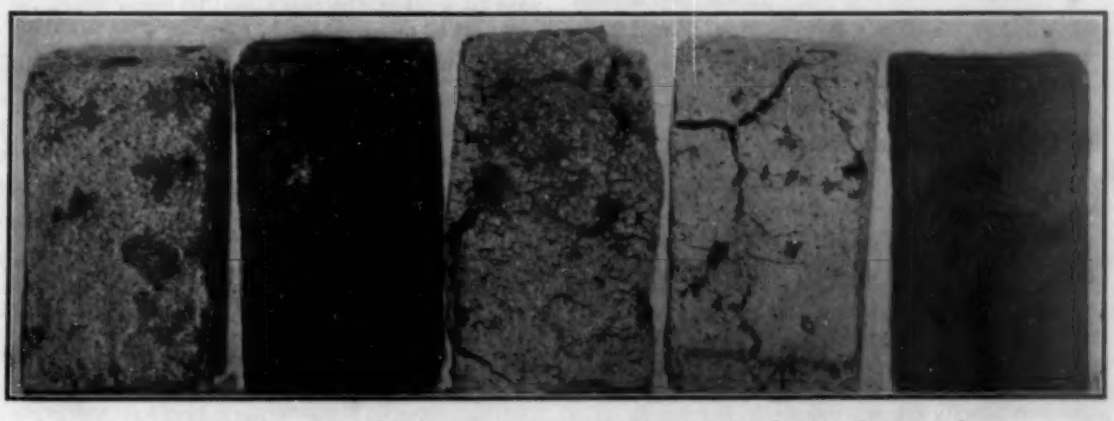

FIG. 8.—Effect of type of firing upon resistance to disintegration (explanation in text).

integrate, and the brick fired in the oxidizing atmosphere should disintegrate, no matter which oxide had been originally added; for a reducing firing should leave all the iron in the form of Fe_3O_4 or FeO, neither of which should deposit carbon in the brick, while the oxidizing firing should leave the iron in the form of Fe_2O_3 which will deposit carbon.

Figures 8 and 9 show how completely justifiable these predictions were. In the case of every brick tested the action was exactly as was expected.

FIG. 9.—Effect of type of firing upon resistance to disintegration (explanation in text).

All of the brick shown in Fig. 8 are from clay A, the explanation for which is given below.

Specimen No.	Oxide added to original clay	Character of firing atmosphere	Remarks
1	Fe_2O_3	Oxidizing	New (no disintegration test was run)
2	Fe_2O_3	Reducing	Not disintegrated
3	Fe_2O_3	Oxidizing	Disintegrated
4	Fe_3O_4	Oxidizing	Disintegrated
5	Fe_3O_4	Reducing	Not disintegrated

All of the brick shown in Fig. 9 were made from clay B as follows:

Specimen No.	Oxide added to original clay	Character of firing atmosphere	Remarks
1	Fe_2O_3	Oxidizing	Disintegrated
2	Fe_2O_3	Reducing	Not disintegrated
3	Fe_3O_4	Oxidizing	Disintegrated
4	None	Reducing	Not disintegrated

In every case, then, it has been shown that the character of the firing and not the original form of the iron is what determines the final susceptibility of the brick to disintegration. Of course, if large deposits of clay could be found in which the iron oxide was very low, then the brick probably would not disintegrate, as shown in Fig. 7. But all the workable deposits of clay seem to have enough iron to be troublesome, so that the disintegration problem must be combated in the firing.

In brickmaking circles, the thoroughly oxidized brick is supposed to be the best, for such a brick is sure to be free from sulfur which is supposed to weaken the brick, and it also seems that sometimes if the iron is not completely oxidized, it acts as a fluxing agent, uniting with the silicates and forming a slag-like iron silicate inclusion ($FeSiO_3$). This compound is considered undesirable, being said to weaken the brick and to cause cracking in the case of changing temperature.

It would seem, then, that owing to the peculiar conditions of this particular chemical reaction involved in disintegration of brick, it might be better to sacrifice some other qualities in the brick for proof against disintegration. A well-oxidized brick may stand wear better, but its superior quality in this respect is of little use if it is torn apart by carbon deposits.

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CERAMIC ABSTRACTS

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Vol. 15 **June, 1936** **No. 6**

Abrasives

BOOK

Abrasive properties of polishing powders. G. G. Lemmlein, E. K. Vander-Flit, and A. V. Shubnikov. *Trudui Inst. Prik. Mineralogii*, No. 69, 16 pp. (1935).—The abrasive properties of natural and artificial abrasive materials of Russian origin were studied with a special apparatus and on the basis of the methods of Mindt (*Schleifmittel Ind.*, Nos. 2 and 5 (1926)); see *Ceram. Abs.*, **6** [8] 316 (1927).

M.V.C.

PATENTS

Abrasive article. G. W. Chormann, F. A. Upper, and B. H. Work (Carborundum Co.). U. S. 2,036,197, April 7, 1936 (May 31, 1933). An abrasive wheel contains an arbor hole, and a plurality of hard metal inserts embedded in the wheel and extending within the arbor hole, the inserts being adapted to accurately engage with a drive shaft.

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Apparatus for determining the toughness of abrasive bodies. R. L. Melton and R. C. Benner (Carborundum Co.). U. S. 2,037,527, April 14, 1936 (Sept. 2, 1930). An apparatus for determining the characteristics of bonded granular articles, etc., comprises a support for the article, a tool adapted to engage the article, the mass of the impacting part being kept constant throughout a series of determinations, electromagnetic means for causing the support and tool to move one relatively to the other for causing an impact of the tool against the article, electromagnetic means for varying the velocity of the impact blow, electromagnetic means for intermittently turning the tool, a gage adapted to indicate the depth of penetration of the tool into the article, and fluid pressure means for removing the detritus from the point of impact.

Automatic grinding machine. B. F. Stowell (Van Norman Machine Tool Co.). U. S. 2,036,658, April 7, 1936 (April 24, 1934).

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prises firing the mixture in the raw condition to mature the bond, and thereafter cooling the bond constituents to solidification and causing the material at the interior portion of the article to be cooled more rapidly than the outer zone and to be put under a compressional stress by contraction of the outer zone which serves to strengthen the wheel.

Indicating device for use in connection with grinding tools. VIKTOR FÖLSCHE. U. S. 2,035,119, March 24, 1936 (July 2, 1934).

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Machine for grinding and surfacing stones. E. H. TRYSELL. U. S. 2,036,841, April 7, 1936 (Aug. 6, 1931).

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Art and Archeology

Greek architectural discovery. EDITORIAL. *Indian Eng.*, **92** [14] 271 (1932).—Excavations at ancient Sykea near Corinth have revealed a building with colonnades, a tiled courtyard, two life-size marble statues, a tomb with terra cotta figurines, a quantity of black glaze pottery, and a headless statue of Artemis. A.P.S.

Humor in pottery. MARGUERITE MAHOOD. *Clay Prod. Jour. Australia*, **3** [4] 7–8 (1936).—The lack of humor in pottery of today is contrasted unfavorably with former times. The ancient Peruvians fashioned figures of fun; the Egyptians made caricatures in clay. Two centuries ago, English potters made Toby jugs and depicted rubicund parsons. H.H.S.

Mosaic finds aid art historians. ANON. *New York Times* (April 9, 1936).—The Committee for the Excavation of Antioch and its vicinity has discovered 250 pieces of mosaic pavements of a quality hitherto unmatched except by those in the Naples Museum. From these pieces, which cover a period from A.D. 100 to A.D. 500, it is hoped to write a missing chapter in the history of late antique painting of the Near East. In the ruins of Pompeii and Herculaneum it has been possible to trace developments of Mediterranean painting into the 1st Century A.D. There has been a gap from this point to the early Byzantine mosaics in the 5th and 6th Centuries. The mosaics found in Antioch will fill this gap. During this period the rational composition of the Greek art with the details of a subject organized around a central axis or motif was replaced by an Oriental unending sequence of equal accents whose only principle of unity was rhythm. The third dimension was no longer used in the 6th Century. M.V.C.

Romance revealed in china. HELEN SPRACKLING. *This Week* [New York Herald Tribune Home Inst.], pp. 16, 21 (March 29, 1936).—A New York china shop celebrated the opening of a new store with an exhibition of the china services of famous persons. The china of Presidents Theodore Roosevelt, Woodrow Wilson, and Franklin D. Roosevelt, of King Edward VIII when he was Prince of Wales, of Princess Mary, and the Viceroy of India are illustrated. When the present White House china was ordered the President stipulated that the service must be on an American china. Although Theodore Roosevelt sixteen years earlier had attempted to find an American china that would be suitable, the present service is the first Lenox china made for the presidential table. Wedgwood, Minton, Lowestoft, Spode, and Chinese porcelain services were also exhibited. H.S.

Variations in color vision and color measurement. T. SMITH. *Phil. Mag.* [Supp.], **20** [136] 1055–62 (1935).—Wide variations in the coördinates of colors which, according to Houstoun (see *Ceram. Abs.*, **10** [3] 166 (1931); **12** [4] 166 (1933)) and Younger, are obtainable by individuals of normal color vision and considered by them an objection to the use of the C.I.E. system, are shown to be due to errors of calculation or theory. The views of these authors on the unreliability of both direct and indirect color measurements on the C.I.E. system are not in agreement with experience at the National Physical Laboratory. P.T.C.

BOOKS

Chinese Art. Edited by LEIGH ASHTON. Introduction by LAURENCE BINYON. Kegan Paul, London, 1935. Price 2s 6d and 3s 6d. Reviewed in *Discovery*, **17**, 23 (1936).—Pottery is discussed by R. L. Hobson, and cloisonné enamel by A. J. Koop. 24 full-page plates. H.H.S.

Photoceramics (Photokeramik). C. FLECK. Union Deutsche Verlagsges., Berlin, 1935. 61 pp. Reviewed in *Chim. & Ind.*, **35** [1] 112 (1936).—The purpose of this process is to reproduce photographic images on porcelain, faience, enamel, and stoneware and to make them indelible by firing. The first method considered uses a chrome salt: a watery solution composed of an adhesive element and a chrome salt has the property of decomposing under the action of light when it is spread thinly and when it dries on a nonporous support; the parts exposed to light become insoluble in water and do not retain the colored powder, while the latter sticks on the parts protected from the light. The preparation of the chrome solution and the chrome layer, the printing of the photographic proof, dusting with the colored powder, and placing the image on the object to be decorated are described. The English method, the iron salts method, the methods of Ninet, Laborde, Pavlovski, and the method by substitution are given. The last part of the work discusses the firing of the image, what colors to use, and fluxes. M.V.C.

PATENTS

Designs for:

Bottle. J. W. BICKS (Carr-Lowrey Glass Co.), U. S. 99,064, March 24, 1936 (Aug. 8, 1935). R. H. DALLAS

(Glass Containers, Inc.), U. S. 99,189, April 7, 1936 (Jan. 17, 1936). C. B. GARWOOD (Carr-Lowrey Glass Co.), U. S. 99,010 to 99,012, March 24, 1936 (Dec. 5, 1935). C. G. HILGENBERG (Carr-Lowrey Glass Co.), U. S. 99,023, March 24, 1936 (Dec. 5, 1935). W. R. LEACH (Carr-Lowrey Glass Co.), U. S. 99,130, March 31, 1936 (Jan. 28, 1936). J. H. STEUERNAGLE (Brockway Glass Co., Inc.), U. S. 98,969, March 17, 1936 (Jan. 20, 1936).

Bowl. A. J. BENNETT. U. S. 98,993, March 24, 1936 (Jan. 13, 1936).

Combination coal and gas range. H. T. BURROW (Malleable Iron Range Co.). U. S. 99,265, April 14, 1936 (Dec. 31, 1935).

Dish. ALBERT KRAUTHEIM (Oneida, Ltd.). U. S. 99,033, March 24, 1936 (Feb. 4, 1936).

Glass building block. H. L. EASTUS (Owens-Illinois Glass Co.), U. S. 99,075 and 99,076, March 24, 1936 (Feb. 12, 1936). W. P. ZIMMERMAN (Owens-Illinois Glass Co.). U. S. 99,102, March 24, 1936 (Feb. 12, 1936).

Goblet. ELMER BELL (Bryce Brothers Co.). U. S. 99,107, March 31, 1936 (Jan. 8, 1936).

Jar. O. C. NOBLE (Tygart Valley Glass Co.), U. S. 99,137, March 31, 1936 (Jan. 15, 1936). T. J. PIAZZOLI (Capstan Glass Co.), U. S. 99,304, April 14, 1936 (March 12, 1935).

Plate. E. J. JOHNSON (Johnson Bros. (Hanley), Ltd.), U. S. 99,031, March 24, 1936 (Jan. 30, 1936). VIKTOR SCHRECKENGOST (Limoges China Co.), U. S. 99,052, March 24, 1936 (Jan. 27, 1936). A. M. WALKER (Bailey-Walker China Co.), U. S. 99,228, April 7, 1936 (Jan. 15, 1936).

Stemmed goblet. ELMER BELL (Bryce Brothers Co.). U. S. 98,909, March 17, 1936 (Dec. 3, 1935). U. S. 99,181, April 7, 1936 (Dec. 3, 1935).

Tumbler. DONALD DESKEY (Libbey Glass Co.), U. S. 99,066 to 99,071, March 24, 1936 (Jan. 29, 1936). K. T. PIPER (Seneca Glass Co.), U. S. 99,138, March 31, 1936 (Jan. 17, 1936).

Method of making decalcomania papers. JOHN MACLAURIN. U. S. 2,036,422, April 7, 1936 (Aug. 10, 1933).

Cements

Absorption of water by Portland cement paste during the hardening process. T. C. POWERS. *Ind. Eng. Chem.*, **27** [7] 790–94 (1935).—P. discusses the change in volume which occurs during the hardening of a mixture of cement and water and which causes an absorption of water when the hardening paste is stored continually under water. The relation of the phenomenon to shrinkage is discussed, and data relating the amount of water absorption to chemical composition of the cement, to water-cement ratio, and to heat of hydration are presented. Illustrated. F.G.H.

Cement progress and research. R. W. CARLSON. *Ind. Eng. Chem.*, **27** [6] 638–40 (1935).—The outstanding trends in the manufacture of Portland cement during the past eighteen years are discussed. The need for investigation of the effect of controllable factors, from the limestone and clay to the finished cement, is emphasized. The following factors are advocated for study: (1) modification of composition to reduce the percentage of noncementing constituents, (2) heat treatment of hot clinker to improve grindability and to modify the structure of the ultimate cement grain, (3) control of atmosphere in kiln and cooler, (4) treatment of cooled clinker to modify its properties and especially to alter the tricalcium aluminate, (5) addition of small amounts of reagents in the finish grind to improve grinding and to improve hydration properties of the cement, (6) control of particle size through the use of air separators to eliminate both the coarsest and finest particles, and (7) removal of impurities which affect the surface condition and general hydration characteristics of cement grains. F.G.H.

Compounds in Portland cement, revealed by high-temperature research on cement compounds. R. H. BOGUE. *Ind. Eng. Chem.*, **27** [11] 1312–16 (1935).—The compounds of Portland cement are defined as a result of high-temperature research upon its components, making use of the phase rule of Gibbs. Positive identification of most of the phases in Portland cement has been made by the use of microscopic and X-ray diffraction methods. The degree of attainment of equilibrium was measured by the test for free lime, and compounds present in a clinker were then computed from the oxide analysis. Since the properties of cement are a function of the compounds, a knowledge of the nature and behavior of these compounds provides information by which the chemical problems of cement and concrete may be examined intelligently. Improvements during the past decade have included higher early strengths, low-heat cement for mass construction, improved volume constancy, improved resistance to salt action, new knowledge of the processes of hydration, and the attainment of color effects. The art has kept pace with the science; the result is extended usefulness, greater security, greater adaptability, and greater satisfaction with concrete. Illustrated. F.G.H.

PATENT

Rotary kilns for burning cement, etc. M. VOGEL-JORGENSEN. Brit. 443,234, March 11, 1936 (Aug. 23, 1934).

Enamel

Adherence of sheet-steel ground coats. W. A. IRVINE. Read before Can. Ceram. Soc., Toronto, Feb., 1936; abstracted in *Can. Chem. Met.*, **20** [3] 68 (1936). E.J.V.

Bibliography of literature on the effect of aluminum in cast iron. Bureau Rept. No. 145. G. R. WOODWARD with notes by J. W. BAMPFLYDE. *Bull. Brit. Cast Iron Research Assn.*, **4** [7] 264–71 (1936).—Fifty-one chronologically listed references are given which do not include textbooks or patents. W.H.B.

Chinatown adopts porcelain enamel. E. GIDLOW.

Better Enameling, **7** [3] 15–16 (1936).—The porcelain enamel store front and sign on the Fong-Fong bakery and ice-cream store in San Francisco's Chinatown are described. Illustrated. E.J.V.

Color oxides for cast-iron and sheet-steel enamels. KENNETH M. HOSSACK. Read before Can. Ceram. Soc., Toronto, Feb., 1936; abstracted in *Can. Chem. Met.*, **20** [3] 68 (1936). E.J.V.

Comparison of results of different instruments for measuring reflectance. G. L. BRYANT AND F. R. PORTER. *Jour. Amer. Ceram. Soc.*, **19** [5] 153–58 (1936).

Correct repair of gray castings by gas-fusion welding with cast iron. H. REININGER. *Giesserei*, **23** [3] 52–57 (1936).—Suitable materials and procedures are described. M.H.

Corrosion of wrought iron and steel. RAYMOND MORGAN, PAUL D. DALSIMER, AND NEWBERN SMITH. *Jour. Franklin Inst.*, **219** [2] 157 (1935).—Rates of corrosion on annealed and unannealed pipe samples of wrought iron, carbon steel, and stainless steel were run in $M/10$ KCl with reference to a $N/10$ calomel cell. In this way three surfaces were studied. Time-potential curves for all samples and surfaces are shown, and the results are briefly discussed and explained. P.T.C.

Porcelain enameling furnaces: II. ANON. *Better Enameling*, **7** [3] 17–21 (1936).—Under continuous furnaces are taken up the rotary, straightaway, duplex straightaway, and "U"-type, and the equipment used with each. For Part I see *Ceram. Abs.*, **15** [5] 145 (1936). E.J.V.

Refining enameler's clay. R. L. CAWOOD. *Chem. Met. Eng.*, **42** [3] 154 (1935).—The method developed for removing undesirable impurities such as iron sulfide, silica sand, and organic matter from enameler's clay consists in drying the clay and then feeding it into a fine-toothed roll crusher. The clay coming from this crusher, which is $^1/_6$-mesh and finer, is run through a high-speed hammer mill which further crushes the clay but does not affect the impurities. This mill produces 200-mesh clay which is separated from the impurities in an air separator, the final step in the operation. The total residue was reduced from 0.5 to 0.0017% and the iron content was reduced from 0.0006 to 0.00006%. M.C.S.

Results with cokes from coal of different geological origin in the foundry cupola furnace. W. HOLLINDER-BÄUMER. *Giesserei*, **23** [4] 73–77 (1936).—Test results with several kinds of coke are given. M.H.

Silicate enamels. ANON. *Verre & Silicates Ind.*, **7** [2] 14–16 (1936).—The adherence and application of enamels to metals are briefly discussed. It is recognized that a surface enamel may have a different coefficient of expansion from that of the metal support by graduating the values of the temperatures of fusion and coefficients of expansion of the intermediate layers. M.V.C.

Steam-jacketed evaporating pans. A. O. ROBSON. *Jour. Australian Chem. Inst.*, **3**, 47–54 (Feb., 1936).—Comparative results are given for enameled, glass-lined, rubber-lined, lead-lined, and other pans. Design and operation and the theory of evaporation are discussed. H.H.S.

PATENTS

Continuous enamelware manufacture. H. T. BEBB (Canton Stamping & Enameling Co.). U. S. 2,035,363, March 24, 1936 (Oct. 12, 1932).

Wall sheathing. H. B. BETTINGER AND J. A. STRUM (Bettinger Enamel Corp.). U. S. 2,037,560, April 14, 1936 (Dec. 8, 1934).

Glass

Analysis of some glasses for modern electric discharge lamps. R. C. CHIRNSIDE. *Jour. Soc. Glass Tech.*, **19** [76] 279–95 (1935).—For the analysis of glasses containing abnormally high proportions of aluminum and phosphorus, suitable methods are described. The use of 8-hydroxyquinoline was of value only in the separation of aluminum and phosphorus, though zinc and magnesium might be determined as the oxyquinolates after they had been separated by classical methods. Modifications of the methods to the semi-micro scale were also discussed. A.A.

Annealing of Pyrex brand chemical-resistant glass. G. W. MOREY. **With an X-ray study.** B. E. WARREN. *Ind. Eng. Chem.*, **27** [8] 966–71 (1935).—The annealing constants of Pyrex brand chemical-resistant glass have been determined and explicit directions are given for the annealing of apparatus made from it. A sample of Pyrex brand chemical-resistant glass was annealed at 430°C, at which temperature it required 2 years for the removal of most of the strain. After an initial period of about 6 weeks, the birefringence diminished in accordance with the empirical equation derived by Adams and Williamson. This initial period of more rapid release of strain is usually present, even at temperatures at which the glass anneals rapidly, but in the experiment lasting 2 years it is more clearly separated from the straight-line part of the annealing curve. The initial period may correspond with the time required for the glass to reach the equilibrium condition for the given temperature, a process which takes place more rapidly than does the actual annealing, while the straight-line portion may correspond to the release of stress in a glass under equilibrium conditions. The theory of annealing is discussed briefly, and a possible alternative explanation mentioned. An X-ray study of the glass, which had been annealed for 2 years at 430°C, indicated that no crystallization had taken place but that there had been a slight increase in regularity in the atomic distribution. Illustrated. F.G.H.

Astrophysical observatory of the California Institute of Technology. The 200-inch reflector. GEORGE E. HALE. *Nature*, **137** [3458] 221–28 (1936).—The problems of making, finishing, mounting, and choosing a location for the 200-inch reflector are explained. 10 photos, one drawing. See also "Mirror—" *Ceram. Abs.*, **13** [8] 204 (1934); "Engineering—" *ibid.*, **14** [11] 273 (1935). J.L.G.

British glass. F. H. STUART. *Pottery Gaz.*, **61** [706] 564–65 (1936).—After a brief history of glass, S. describes the manufacture of glass, explains the terms "flint" or "crystal" glass, describes the glass furnaces used, and summarizes the manufacture of colored glass. The process of making art glass pieces is discussed in detail. E.J.V.

Cast iron for the manufacture of glass bottle molds. N. L. Evans, W. Goacher, and J. E. Hurst. *Jour. Soc. Glass Tech.*, **20** [77] 45–53 (1936).—Refined pig iron is suitable for glass bottle molds as it is machineable and capable of taking a good polish and withstanding elevated temperatures, besides being of moderate price. A proposed specification of the composition of refined pig iron suitable for glass bottle molds is total carbon 3.1% (maximum), sulfur 0.07 (maximum), phosphorus 0.45 (maximum), manganese 0.8 to 1.5, the silicon content varying according to the thickness of the casting. Two such pig irons of different silicon contents covered, by appropriate mixtures, all casting thicknesses from $^3/_8$ to $1^3/_4$ in. Little change in composition occurred if the raw materials were melted in crucibles, but allowance was made for the increased carbon and decreased silicon contents brought about by cupola melting. The molten metal was partly desulfurized and refined in the ladle by treatment with 1% granular sodium carbonate. A.A.

Cellulose ether as intermediate layer for safety glass. F. Ohl. *Keram. Rundschau*, **42** [45] 563–64 (1934).—Cellulose-ether derivatives are not often mentioned in technical literature although their use for safety-glass manufacture is increasing. Ethyl and benzylcellulose are superior to cellulose esters on account of insensibility to light and saponification agents, adherence to smooth surfaces, and high thermoplasticity. Benzylcellulose is resistant to steam and absolutely indifferent to water. Its mechanical resistance to shock is above average. In the U. S. its use has reached the industrial stage; in Germany, ready sheets are not marketed. Manufacture of such sheets by safety-glass works is easy and economical. The plant and solvents for and recuperation of these sheets are described. Edge protection may be dispensed with. Practical tests have shown the superiority of the ether derivatives particularly at low temperatures. See also "Safety—" *Ceram. Abs.*, **15** [4] 118 (1936). F.E.V.

Chemical resistibility of quartz laboratory glass. M. A. Besborodov and F. A. Lade. *Zavodskaya Lab.*, **4** [5] 574–77 (1935); see *Ceram. Abs.*, **15** [2] 58 (1936). P.B. & E.S.

Control of glass furnaces. W. Maskill. *Jour. Soc. Glass Tech.*, **19** [76] 312–18 (1935).—Furnace management, whether dependent on details of construction or by the application of various methods of control, is discussed. **Discussion.** Anon. *Ibid.*, **20** [77] 5–15 (1936).—Four papers are discussed. A.A.

Course in glassmaking. D. R. *Verre & Silicates Ind.*, **7** [1] 4–6 (1936).—The study of the combustion of gas is continued. See *Ceram. Abs.*, **15** [5] 147 (1936). M.V.C.

Determining stones in glasses. M. A. Besborodov. *Keram. i Steklo*, **11** [12] 27–36 (1935).—A detailed discussion is given of various methods used to identify stones in glass, including (1) magnifying glass, (2) soda treatment, (3) petrographic method, (4) studying striae, (5) simplified chemical analysis, (6) graphical method for determining the composition of stones, and (7) treating with solutions. Examples are given of the identification of stones, such as quartz and cristobalite in grog stones, corundum and mullite in grog stones of window glass, crystallizing of bottle glass with the formation of wollastonite and devitrite, black stones in green glass, crystallization of Fourcault window glass, and the formation of cristobalite. Numerous tables with characteristics of stones and other data are given. M.V.C.

Devitrification phenomena caused by improper melting. E. Felsner. *Keram. Rundschau*, **43** [5] 52 (1935).—Devitrification is usually ascribed to oversaturation of one component in glass or to the improper working of the furnace. F. quotes two instances of (erroneously named) devitrification. A flint-glass covered pot was left half open to prevent overheating. At first the glass was perfectly plain, but during work minute translucent sand grains appeared. An opal glass pot was also left half open to avoid burning out. Fine seeds or a fatty layer on the glass surface resulted. F.E.V.

Disappearance of a cause of anisotropy of glass by reheating. Jean Herbert. *Compt. rend.*, **202** [3] 214–15 (1936).—The anisotropy and the structural layers of window glass were studied and found to be due mostly to the chemical heterogeneity of the glass and to the manufacturing processes. The different zones or layers are attacked by HF in different degrees; values are given for different glasses. By reheating a glass pane sufficiently long (30 to 40 hr.), the zones disappear by merging into each other; HF then attacks uniformly. Reheating homogenizes the glass and eliminates the interior stresses which make it anistropic. M.H.

Distribution of heat losses in a tank-furnace system. H. S. Y. Gill. *Jour. Soc. Glass Tech.*, **19** [76] 319–29 (1935).—The tank furnace investigated was a two-port regenerative furnace fired with producer gas, with a melting area of 135 sq. ft., and producing approximately 50 tons of electric light bulbs per week. The main losses, expressed as a percentage of the heat content of the coal, were 22.3% in the producer and flue to the gas valve, 37.2% from the furnace structure, and 7% from the regenerators and 25% stack loss, of which the excess air used for combustion accounted for 2.5%. The efficiency of the furnace was 7.3% and of regeneration 57%. The loss from the crown was reduced from 6 to 3% by the application of insulation. A comparison of the heat balance was made with those published previously for 3 larger furnaces, efficiencies of which varied from 10 to 19.1%. A.A.

Effect of alumina upon the chemical durability of sand-soda-lime glasses. A. K. Lyle, William Horak, and Donald E. Sharp. *Jour. Amer. Ceram. Soc.*, **19** [5] 142–47 (1936).

Effect of alumina on the melting rate of a soda-lime-magnesia-silica glass. C. W. Parmelee and W. B. Silverman. *Glass Ind.*, **17** [4] 111–14 (1936).—It was found that (*a*) additions of alumina decrease the melting rate and its effect decreases with rising temperatures; (*b*) if the final crystalline phase is silica, then the rate of solution is chiefly influenced by the viscosity; and (*c*) in so far as solution time is concerned the use of 7% alumina in ordinary soda-lime-magnesia-silica glasses would not be prohibitive. E.J.V.

Electric furnaces. A. Salmony. *Verre & Silicates Ind.*, **7** [1] 3–4 (1936).—The operation and advantages of electric furnaces in glass plants are discussed. M.V.C.

First big American telescope mirror: John Peate, his

lens. F. W. PRESTON. *Bull. Amer. Ceram. Soc.*, **15** [4] 129–52 (1936).

Glass batches and their preparation from 1860 to 1890. F. JOCHMANN. *Glashütte*, **65** [45] 703–705; [46] 719–22; [49] 770–72; [50] 780–83; [51] 797–99 (1935); **66** [1] 4–6 (1936).—A detailed description of the composition and production of various kinds of glasses in the second half of the 19th Century is given. M.V.C.

Glass blocks resist sun heat. OWENS-ILLINOIS GLASS CO. *Nat. Glass Budget*, **51** [43] 16 (1936). M.C.S.

Glass, an indispensable factor in modern civilization. ALEXANDER SILVERMAN. *Jour. Franklin Inst.*, **220** [5] 539 (1935).—The development of modes of manufacture of different types of glass and their present-day states of advancement are presented. Examples of civilization's dependence upon glass as a commodity are given. P.T.C.

Heating glassmelting furnaces: practice and future tendencies. J. LAMORT. *Glashütte*, **65** [43] 669–73 (1935).—Present-day developments in heating glassmelting furnaces by gas, electricity, oil, and pulverized fuel are described. (1) Experience with a special kind of generator gas carburizing, (2) difficulties with electric heating of glass furnaces, (3) oil and coal-dust firing, and (4) blasting fuel gas into the melted glass mass are discussed. M.V.C.

Influence of the alkalinity of glasses on viscosity of diluted ether-alcohol collodions. JEAN GRÉVY. *Compt. rend.*, **202** [6] 480–82 (1936).—It was observed that certain diluted ether-alcohol collodions showed, after a month, a fairly appreciable decrease of viscosity. This decrease was greater the greater the ratio of the glass surface to the liquid volume. It was found that the alkalinity of the glass container causes this decrease, which was about 15 times less in Pyrex brand glass than in ordinary glass. This fact should be taken into account when viscosity measurements are made. M.H.

Irregular firing of pot furnaces. HANS BAUMER. *Glashütte*, **65** [44] 687–89 (1935).—The importance of uniform heating in pot furnaces and the effect of irregular heating on glassmelting are discussed. M.V.C.

Is hardened glass a safety glass? A. H. KÄMPFER. *Glashütte*, **65** [38] 588–92; [39] 605–609 (1935).—A theoretical discussion is given. M.V.C.

Jacketed industrial glass heat exchanger. H. C. BATES. *Ind. Eng. Chem.*, **27** [3] 273–75 (1935).—A plant-scale glass heat exchanger made of Pyrex brand chemical-resistant glass is described and illustrated. See *Ceram. Abs.*, **13** [4] 85 (1934). F.G.H.

Jean Carre's glass furnaces. S. E. WINBOLT. *Jour. Soc. Glass Tech.*, **20** [77] 16–18 (1936). A.A.

Joining the edges of glass in the manufacture of non-shatterable glass. A. BRESSER. *Keram. Rundschau*, **42** [5] 59 (1934).—To prevent deterioration of the intermediate layer, edges are joined with a beeswax or pitch mastic. A compound of 1 part celluloid, 1 amylacetate, 5 acetone, 1 alcohol, and 2 sandarac is excellent. The inner surface of glass sheets is bevelled. It is difficult to insert correctly an intermediate layer slightly smaller than glass sheets. Excess of layer has to be solved by a mix of 80% technical acetone and 20% water. Acetylcellulose dissolves in acetic acid, methyl acetate, or 1/1 ether-alcohol. The intermediate layer gives a gel which should be removed. A lead paint, metallic lead (0.1 to 0.2 mm. thickness), water glass with MgO or ZnO may be used as mastic. Gutta percha solved in chloroform is not recommended. See "Sealing—" *Ceram. Abs.*, **14** [9] 215 (1935). F.E.V.

Laboratory analysis of beer in bottles and cans. ANON. *Nat. Glass Budget*, **51** [48] 7 (1936).—A comparison is made showing the effects resulting from storing beer in glass bottles and metal cans over a period of 13 weeks. The tests seem to prove that there is no change in the taste, odor, or chemical constitution of glass bottled beer, while the beer contained in metal cans does show a decided change in taste and odor and a slight change chemically. M.C.S.

Meditations, speculations, aspirations. B. P. DUDDING. *Jour. Soc. Glass Tech.*, **19** [76] 244–58 (1935).—In his presidential address before the Society of Glass Technology, D. reviews its activities in three sections, academic, practical, and social, and indicates some of the unexplored avenues of research. Regarding the constitution of glass, the evidence obtained by the direct methods (X-rays and electronic rays) suggests the presence of small crystallites in the glassy substance. The place of these crystallites in the structure of glasses and their influence on glass properties (particularly strength, gas absorption, and gas diffusivity) have opened up fields for research. In connection with the applied research, the theory of probability and technological problems were discussed. The solution of the practical problems should not be given precedence over the more fundamental research. A study of the theory and practice of industries having some likeness to glass is believed to have considerable value. The subject of social relations was also discussed. A.A.

Mineral wool from wollastonite. JOHN T. THORNDYKE. *Mining & Met.*, **17** [351] 133–35 (1936).—Using wollastonite as the raw material and accepted processes of manufacture, T. studied the controlling influence of color and length and quality of fiber and the melting means. Use of the electric arc furnace and a simple charge of wollastonite gave a snow white, extremely long-fibered wool with almost total absence of shot glass and nonfibrous material. It is superior to other accepted and recognized products; it has a higher melting point and is more resistant to acid attack than wool produced from other charges. Advantageous features of wollastonite rock wool are listed. E.J.V.

Mirrors obtained by evaporation in vacuum. L. DUNOYER. *Compt. rend.*, **202** [6] 474–76 (1936).—The replacement of Ag by Al on glass mirrors is discussed. To obtain a well-adhering Al film by the vacuum method, it is necessary that the molecules of the evaporated metal encounter the least possible number of molecules of the residual air before they strike the surface on which they are to stay. The conditions under which this can be realized are discussed and a few methods described. M.H.

Organic glasses. G. T. MORGAN, N. J. L. MEGSON, AND E. LEIGHTON HOLMES. *Jour. Soc. Glass Tech.*, **20** [77] 19–34 (1936).—The constitution and properties of hard, transparent condensation as well as polymerization resins (organic glasses) are reviewed. The problems of the molecular structure and of methods of improving the hardness and durability of the resins for commercial purposes are discussed. Reference is made to various commercial prod-

ucts derived from resins, and a comparison is made in a tabular form of the general and physical properties of organic glasses and commercial inorganic glasses. Synthetic resins possess some but not all the properties desirable in glass. They fail generally in being comparatively expensive, less stable than glass under diversified condition, and frequently, in possessing comparatively low softening points, high water absorption, and low hardness values. Among the advantages transparent resins possess are flexibility, low brittleness, and suitability for machining. A.A.

Phials (ampoules). A. MAURI. *Ind. Vetro Ceram.*, **8** [3] 87–98 (1935).—The manufacture of glass tubes and ampoules intended for hypodermic injections is outlined. The phials are submitted to sterilization at 180°C and, after filling with serum, to tyndalization at 50°C. Chemical neutrality of glass is essential; Pb, Zn, Sb, and As are not tolerated. F.E.V.

Physiological and medical significance of glass. HANS SCHULTZ. *Glashütte*, **65** [40] 623–26 (1935).—A general discussion is given of glass composition and properties and of its extensive use as a protection against radiation and for storing sensitive reagents and medicines. The testing of medical and ampoule glass is briefly discussed. M.V.C.

Plastics used in the manufacture of laminated safety glass. J. WILSON. *Jour. Soc. Glass Tech.*, **20** [77] 35–44 (1936).—An outline is given of the composition and properties of celluloid. A method of measuring the brittleness of a piece of laminated glass by the fall of an iron bolt on an unsupported area from varying heights is described. Steady increase in brittleness of a laminated glass with a celluloid interlayer upon the exposure to light is explained. The composition and properties of celluloid acetate plastic and of synthetic resins are considered in relation to the manufacture of laminated safety glass. Requirements of a safety-glass interlayer are that it must be (1) nonbrittle; the impact bursting strength of a firmly clamped sheet, 3 in. square and 0.020 in. thick should not be less than $3^{3}/_{8}$ ft.-lb. applied by a $^{3}/_{4}$-lb. bolt; (2) transparent, possessing a light transmission not less than about 80% in a thickness of 0.02 in.; (3) uniform in texture and in refractive index, and free from objectionable foreign matter such as dust, hairs, etc.; (4) available in a form suitable for mass production methods of lamination, *i.e.*, in sheet form; (5) capable of being cemented firmly and permanently to glass by mass production methods; (6) stable to light and infrared radiation; and (7) available in quantity and at a commercial price. A.A.

Producer gas plant in glass manufacture. F. J. HURLBUT. *Jour. Soc. Glass Tech.*, **19** [76] 330–38 (1935).—H. draws attention to a few points which deserve consideration when a plant is laid down to supply raw gas for a glass-melting furnace. These points include the size of the producers, gas mains, cost of power and steam operation, choice of coal, and handling the coal and ash. A regulator, which was found satisfactory in controlling the presence of the producer gas supply, is described. A short survey of the possibility of replacing town gas by clean producer gas is also given. A.A.

Recent developments in metals sealing into glass. HOWARD SCOTT. *Jour. Franklin Inst.*, **220** [6] 733 (1935).—Addition of cobalt to low-expansivity nickel steels reveals that a given low expansivity can be obtained to a much higher temperature; such an iron-base alloy can be sealed into hard glass having an expansivity as low as 3.6×10^{-6}/°C with a strain point up to 470°C. Kovar, having an optimum cobalt content, is most suitable. The theory of glass-to-metals seals and the stress relations developing therefrom are discussed. The advantages of Kovar over other metals containing W and Mo are discussed. P.T.C.

Resistant glasses for modern electric discharge lamps. J. H. PARTRIDGE. *Jour. Soc. Glass Tech.*, **19** [76] 266–78 (1935).—Glasses suitable for the construction of the inner envelopes of a high-pressure mercury-type electric discharge lamp were obtained by using compositions of approximately 50% silica, little or no alkali, 20% alumina, and a high content (at least 16%) of lime or of calcium, zinc, and barium oxides. The effect of other oxides was also studied. The glasses were low in iron content, had a softening temperature of the order of 900° (= viscosity $10^{6.5}$ poises), and had a minimum electrical resistance of 2 megohms at 600°. The glass melting was done in special refractory pots at 1450° to 1480°. For a number of glasses physical properties, such as thermal expansion, viscosity, and thermal endurance, were determined. Glasses resistant to sodium vapor lamps had an iron content as low as 0.02% and contained 0 to 25% silica, 10 to 30 alumina, 30 to 50 boric acid, 0 to 30 barium oxide, 10 calcium oxide, and other oxides in smaller amounts. Because the glasses were fluid and extremely corrosive, finding suitable refractory materials offered difficulties. A.A.

Safety glass. PITTSBURGH PLATE GLASS CO. *Glass Ind.*, **17** [4] 131 (1936); see *Ceram. Abs.*, **15** [5] 147–48 (1936). E.J.V.

Sandwich glass: III. ALEXANDER SILVERMAN. *Glass Ind.*, **17** [4] 127–31 (1936).—The red and pink glasses using gold and copper as the basis of coloring the glass, found in the batch record of William E. Kern and George L. Fessenden, are discussed at length. For Part II see *Ceram. Abs.*, **15** [5] 148 (1936). E.J.V.

Second International Congress on Glass. W. E. S. TURNER. *Bull. Amer. Ceram. Soc.*, **15** [4] 168 (1936).

Significance of glass technical knowledge for glass production. ANON. *Glashütte*, **65** [42] 651–54 (1935).—Glass properties, especially viscosity and devitrification, are discussed and a literature index is given. M.V.C.

Simultaneous measurement of viscosity and electrical conductivity of some fused silicates at temperatures up to 1400°. M. P. VOLAROVICH AND D. M. TOLSTOI. *Jour. Soc. Glass Tech.*, **20** [77] 54–60 (1936).—Viscosities and electrical conductivities of silicates, consisting of a mixed alkali-lime-silica glass, two slags, two enamels, and a natural lava were measured between 780° and 1400°. For the two slags, discontinuities in the viscosity and conductivity curves were obtained due to crystallization; for the glass, smooth curves were obtained in each case, and for the natural lava, curves of an intermediate type. The relation of $\eta \cdot K^{1.4} = 1.65$ held for the glass for the range 700° to 1000°, and similar relationships were found for the two slags. A.A.

Solid or hollow, lamp-blown glass cocks? EMBE. *Glas & App.*, **17** [5] 41 (1936).—The lamp-blown hollow cock is less fragile than solid types. M.H.

Spectro-polarimeter with metallic mirrors for the far ultra-violet. R. SERVANT. *Compt. rend.*, **202** [6] 476–77 (1936).—The difficulties of polarimetric measurements in the ultra-violet of wave-length lower than 2500Å are explained. These may be overcome by using aluminized concave Al mirrors instead of lenses, which give good results down to 1850Å or lower. The method of measurement is described. M.H.

Story of glass. J. C. HOSTETTER. *Bull. Amer. Ceram. Soc.*, **15** [4] 166–67 (1936).

Volatilization of lead oxide from lead oxide-silica mixtures. E. PRESTON AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **19** [76] 296–311 (1935).—A series of mixtures ranging in composition from 53.96 to 99.80% PbO, corresponding to 24 to practically 100 mol. per cent, were prepared. By rapid cooling, glasses were obtained up to 90.05% PbO. The initial rates of volatilization in mg./cm.²/hr. varied from 0.10 to 11.6 at 900°, 0.20 to 80.0 at 1000°, 1.1 to 250 at 1100°, 2.0 to 254 at 1200°. Because of the high volatility of the last two members of the series no measurements were made beyond 1100°. The first two members were devitrified at 900°. The temperature-volatility relationships approximated to a vapor-pressure law. The existence of the silicates, $PbO \cdot SiO_2$, $2PbO \cdot SiO_2$, $4PbO \cdot SiO_2$, was indicated by the relationship between concentration and loss by volatilization. This view was confirmed by further relationships involving the progress of volatilization with time. The combined heats of decomposition and evaporation were 56,000, 49,000, and 30,000 cal./g. mol., respectively. Ideal conditions for the volatilizations were marred by the density effects in the melts, but the results obtained generally confirmed those of the earlier work on alkali-silica glasses. The calculated pressures of PbO at 1200° ranged from 0.7 to 72 mm./Hg for the first 12 glasses. The vapor pressure of pure PbO at 1100° was calculated to be 70 mm. Hg. A.A.

Water-cooling glass tanks. ANON. *Glass Ind.*, **17** [4] 116 (1936).—Two methods of water cooling are (1) to spray water directly onto the outside block surface and (2) to circulate cold water through a metal pipe or box placed in contact with the block. Disadvantages of both methods are pointed out. Water cooling in the early stages of the furnace run seems to be needless and expensive, but it has its merits when the tank is worn out and production has several weeks to go. E.J.V.

X-rays for investigating the structure of glasses. N. N. VALENKOV. *Zavodskaya Lab.*, **4** [11] 1351–59 (1935). P.B. & E.S.

X-ray studies of crystalline substances in glasses. VICTOR HICKS. *Jour. Amer. Ceram. Soc.*, **19** [5] 148–52 (1936).

BOOKS

Coloring and opacifying of glass. I. I. KITAIGORODSKIĬ AND SCIENTIFIC COLLABORATORS. State Scientific Institute of Glass of U.S.S.R., Moscow, 1935. 295 pp. Price 5R, 50k.—This is a compilation of a series of studies made by the Institute of Glass and deals with (1) influence of glass composition on the absorption of light; (2) theory and practice of the production of ruby glasses, (3) method of calculating Fresnel lenses for automatic signaling on railroads, (4) production of Fresnel lenses at the Institute of Glass, (5) organization of the production of Fresnel lenses in U.S.S.R., (6) theory and practice of the production of ultra-violet glasses, (7) theory and practice of the production of opal glasses, and (8) photoluminescence and absorption of light of uranium glasses. Bibliography of more than 700 references. M.V.C.

Effect of purifying and oxidizing agents on the color tone of glasses with different iron content (Über die Einwirkung von Läuterungs- bzw. Oxydationsmitteln auf den Farbton von Gläsern mit verschiedenem Eisengehalt). K. SCHMIDT. Technische Hochschule, Berlin, 1934, 50 pp. Reviewed in *Chim. & Ind.*, **35** [2] 350–51 (1936).—The effect of certain elements on the color of glasses containing iron oxide was studied. A review of literature on iron silicates, alkaline silicates, color of iron oxides, dissociation of Fe_2O_3, glasses containing Fe_2O_3 and FeO, and the measurement of absorption in glasses containing iron is given. A description of the method of procedure and of the materials used in the glasses follows. The norms of Ostwald were used to estimate the color, and the absorption curves were established with the Koenig-Martens spectrophotometer. The principal results obtained are as follows: When the iron content increases, the color turns from blue-green to green, then yellow-green; the nitrates displace the color toward yellow (sodium nitrate acts more energetically than barium nitrate); sodium sulfate displaces the color toward green, and barium sulfate toward blue; arsenic displaces toward yellow; and fluorspar and cerium oxide toward yellow and red. M.V.C.

Mechanical Production of Glass. A. VENDELER. Translated from German into Russian by I. S. SHUR. Ukrgizlegprom. Kharkov, 1934. 195 pp. Price 5R. The book deals chiefly with (1) pressing, stamping, and rolling glass products, (2) mechanical blowing, and (3) mechanical drawing of glass. M.V.CONDOIDE

Textbook on glassmaking: Vol. III. (Cours de verrerie). EMILIO DAMOUR. Librairie Polytechnique Ch. Beranger, Liége. 273 pp. Price 110 Belgian francs. Reviewed in *Verre & Silicates Ind.*, **7** [4] 44 (1936).—Volume I treated of the chemistry of glass, Vol. II, fusion and physical properties when hot, and Vol. III concerns cooling, working glass by hand and machine, and the physical properties when cold. The three volumes constitute an important and excellent contribution to French technical literature. For Vol. II see *Ceram. Abs.*, **11** [8] 451 (1932). M.V.C.

Working glass articles. I. S. SHUR. Ukrgizlegprom, Kiev, 1934. 118 pp. Price 3R. M.V.CONDOIDE

PATENTS

Apparatus for etching glass articles. C. V. ACHAUER AND LORENZO PRICE (Hazel-Atlas Glass Co.). U. S. 2,036,647, April 7, 1936 (March 27, 1934).

Apparatus for feeding molten glass. A. E. HAMILTON. U. S. 2,035,958, March 31, 1936 (Nov. 8, 1933).

Apparatus for producing sheet glass. J. E. MAMBOURG (Libbey-Owens-Ford Glass Co.). U. S. 2,035,272, March 24, 1936 (Dec. 23, 1933).

Automatic glassblowing machines. N. V. MIJ. TOT EXPLOITATIE VAN UITVINDINGEN. Brit. 444,637, April 8, 1936 (Sept. 26, 1933).

Eddy current control for leers. C. S. RILEY (Hartford-

Empire Co.). U. S. 2,037,392, April 14, 1936 (March 1, 1933).

Forehearth for molten glass. W. T. Honiss (Hartford-Empire Co.). U. S. 2,036,872, April 7, 1936 (July 17, 1935).

Glass-cutting apparatus. William Owen (Pittsburgh Plate Glass Co.). U. S. 2,036,294, April 7, 1936 (July 26, 1935).

Glass-feeding machine. Frank O'Neill (Hartford-Empire Co.). U. S. 2,034,055, March 17, 1936 (June 23, 1926; renewed Sept. 1, 1932).

Glass-grinding apparatus. F. B. Waldron (Pilkington Brothers, Ltd.). U. S. 2,036,900, April 7, 1936 (March 9, 1935).

Glass-molding material. O. K. Carpenter (Duraloy Co.). U. S. 2,035,364, March 24, 1936 (Jan. 25, 1934). A cast metal article for use in contact with hot plastics, such as molten glass, contains from about 16 to about 20% of chromium, from about 1 to about 2% of carbon, the remainder being iron, the article being highly resistant to the formation of surface cracks, being readily machineable, and being capable of imparting a high luster to glassware contacting therewith while in a plastic condition, over wide temperature ranges and during long periods of use.

Glassware-forming machine. L. D. Soubier and J. R. Hoge (Owens-Illinois Glass Co.). U. S. 2,034,887, March 24, 1936 (May 16, 1934).

Heat-absorbing glass. D. E. Sharp and James Bailey (Mississippi Glass Co.). U. S. 2,034,994, March 24, 1936 (June 26, 1933). In the production of heat-absorbing glass containing iron in substantially the ferrous condition only, a batch is melted containing iron, antimony oxide, and metallic aluminum as a reducing agent.

Hollow building block. Games Slayter, J. S. Irvine, and J. H. Thomas, Jr. (Owens-Illinois Glass Co.). U. S. 2,034,925, March 24, 1936 (Dec. 14, 1932; renewed Sept. 4, 1935).

Hurricane-lamp glasses. A. Kenyon & Co., Ltd., and C. W. Gorton. Brit. 444,835, April 8, 1936 (Dec. 20, 1934).

Joining or cementing glass building units. Corning Glass Works. Brit. 444,720, April 8, 1936 (May 21, 1934).

Machine for forming hollow glass articles. L. D. Soubier (Owens-Illinois Glass Co.). U. S. 2,034,844, March 24, 1936 (May 18, 1934).

Manufacture of composite objects of tempered glass. Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey. Brit. 443,536, March 11, 1936 (July 4, 1934).

Manufacture of hardened or tempered glass. Assurex le Roi des Verres de Securité Magnien, Monnier, & Cie. Brit. 443,804, March 18, 1936 (Dec. 27, 1934).

Manufacture of ornamental coated glass articles. F. D. Cheney. U. S. 2,036,021, March 31, 1936 (Dec. 23, 1933).

Method and apparatus for bending glass tubing. British Thomson-Houston Co., Ltd. Brit. 443,480, March 11, 1936 (Oct. 12, 1934).

Method and apparatus for forming glassware. G. E. Howard (Hartford-Empire Co.). U. S. 2,036,333, April 7, 1936 (March 21, 1934).

Method of fining borosilicate glasses. H. P. Hood (Corning Glass Works). U. S. 2,035,318, March 24, 1936 (May 8, 1934). The method of making a reduced borosilicate glass which is substantially free from bubbles includes adding to the batch therefor from 2 to 5% of a chloride and a sufficient amount of reducing agent to keep the iron reduced and to counteract any oxidizing action of the chloride, and melting the batch under conditions which will vaporize and drive off a substantial part of the chloride.

Method of forming parisons for bottles, etc. W. T. Honiss (Hartford-Empire Co.). U. S. 2,036,871, April 7, 1936 (Nov. 1, 1934).

Method of glass feeding. S. G. Stuckey (Obear-Nester Glass Co.). U. S. 2,033,950, March 17, 1936 (July 27, 1932).

Method and means for making multifocal lenses. H. J. Newell (Bausch & Lomb Optical Co.). U. S. 2,035,827, March 31, 1936 (May 27, 1933).

Mold and method of manufacturing. Henri George (Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey). U. S. 2,037,228, April 14, 1936 (Dec. 30, 1933). In the art of manufacturing molds, the steps consist of lining an enclosure with granules of a granulated refractory material having a fusion point higher than the substance to be molded to form a hollow refractory mold having inner surfaces which come in contact with a molten substance when the mold is being used for the purpose of making a casting, and fusing those portions of the mold which are nearest to the inner surfaces, the portions being solidified before a molten substance is brought in contact with the inner surfaces for the purpose of making a casting.

Multifocal lens. Scott Sterling (Bausch & Lomb Optical Co.). U. S. 2,035,846, March 31, 1936 (Nov. 12, 1932).

Ophthalmic lens and method of making. D. D. Hubbell (Optical Research Corp.). U. S. 2,037,327, April 14, 1936 (March 14, 1934).

Plate-glass casting apparatus. J. D. McLeod (Pittsburgh Plate Glass Co.). U. S. 2,036,228, April 7, 1936 (June 21, 1933).

Process and apparatus for the continuous manufacture of sheets of undulated glass. Soc. anon. des manufactures des glaces et produits chimiques de St.-Gobain, Chauny, et Cirey. Brit. 443,686, March 18, 1936 (July 31, 1934).

Process for coating glass sheets. Kikujiro Morita. U. S. 2,034,987, March 24, 1936 (May 28, 1932).

Regulating pressure on glass polishers. Pilkington Bros., Ltd. Ger. 617,698, July 8, 1935 (May 17, 1934), XII–67*a*, Gp. 33 [addition to Ger. 600,428]; *Jour. Soc. Glass Tech.*, **19** [76] A400 (1935).—A hydraulic pressure is applied to the tools so that each is maintained in contact with the work with the same uniform pressure.

Sealing electric conductors into glass, etc. A. West & Co., Ltd., and E. Babler. Brit. 444,138, March 25, 1936 (Feb. 19, 1935).

Signal lens. C. V. Bergstrom (Corning Glass Works). U. S. 2,034,603, March 17, 1936 (Feb. 5, 1934; renewed Aug. 24, 1935).

Toughening glass. W. J. Tennant (Assurex le Roi des

Verres de Securité Magnien, Monnier, & Cie.). Brit. 444,317, April 1, 1936 (Sept. 11, 1934).

Transference of glass bottles, jars, etc., to leers. WALTER FORSTER. U. S. 2,037,623, April 14, 1936 (April 20, 1935).

Structural Clay Products

Drying de-aired bodies. W. BARRETT. *Proc. Nat. Paving Brick Assn.*, p. 75 (1935).—The conditions necessary for successfully drying de-aired bodies are not much different from those usually followed in the well-controlled drying of nonde-aired bodies. The mechanics of drying in both cases are much alike. The chief factors concerned are (1) grain size of the material, (2) degree of pugging, and (3) proportions of plastic to nonplastic in the body. M.C.S.

Effect of equal temperature distribution and cooling problems. G. R. ROBINSON. *Proc. Nat. Paving Brick Assn.* p. 79 (1935).—Through proper de-airing of paving brick clay, a unit can be produced which requires a lower finishing temperature in firing and permits a longer soaking period at a lower temperature. This longer soaking period permits more uniform firing throughout the kiln with a resultant increase in production and improvement in the size, color, density, and shape of the unit. The cooling procedure followed for de-aired brick is not essentially different from that followed for nonde-aired brick. M.C.S.

Ghandi Road. EDITORIAL. *Indian Eng.*, **92** [18] 348 (1932).—The experimental Ghandi Road in Texas is described, in which a layer of cheap cotton fabric is inserted between the surface of the road and the foundations. It is claimed that this will facilitate repairs without damaging the base. A.P.S.

Manganese flashing improves brick appearance. LEE MORSE. *Brick Clay Rec.*, **88** [3] 104 (1936).—Brick which formerly were a cross between salmon and red in color were flashed by two additions of 75 lb. of manganese 5 min. apart at the finishing temperature of the kiln, resulting in rust colors, "pimple" brick, deep cherry reds, gradations of rust and deep reds, and some gunmetal in color with glossy surfaces. E.J.V.

Modern practices in brick paving as applied to city streets. LYONS MUSSINA. *Dependable Highways*, **122** [6] 3 (1931).—M. discusses the improved methods of preparing the subgrade, bases, and cushions for brick-road construction. Owing to the continual improvement in the quality of paving brick and a standardization of the size, more uniform and serviceable pavements are being built. A brick with a moderate lug is the most desirable because of the better possibility of filler admittance to all of the joints. M.C.S.

Paving brick in sewer construction. ANON. *Dependable Highways*, **149** [4] 6 (1935).—Paving brick which do not quite meet the rigid specifications for paving units serve well in sewer construction. Many installations of this grade brick have withstood the abrasive action and chemical attack encountered in sewers satisfactorily. M.C.S.

Physical properties of de-aired paving brick. R. B. KEPLINGER. *Proc. Nat. Paving Brick Assn.*, p. 81 (1935).—K. points out the possibilities for variations in physical properties of de-aired clay products unless close control of the de-airing operations is effected. De-airing may improve a body, but only by the necessary control can it improve the quality and maintain the desired uniformity. M.C.S.

Sand-lime brick. J. G. M. BEVAN AND A. H. FLOWERDEW. *Indian Eng.*, **92** [13] 255–56 (1932).—The authors describe the method of making sand-lime brick at the Serdang plant of the original Sand-Lime Brick, Ltd., formed in 1921 and later converted to Bricks, Ltd., in 1927. The essential principle is to mix 8% lime with 92% sand, press the mixture in molds, and harden the brick in steaming chambers. The steaming process results in the formation of a new chemical compound called hydrocalcium silicate, which binds the material into a hard, smooth, close-grained, and homogeneous brick. A sand-lime brick is thus a manufactured sandstone. A.P.S.

Standardization of brick dimensions. ANON. *Brit. Clayworker*, **44** [526] 335 (1936).—The British Standards Institution has issued a specification entitled "Clay Brick Sizes." R.A.H.

Stoneware pipe in sewerage installations. ANON. *Clay Prod. Jour. Australia*, **3** [4] 1–2, 11, 17, 30 (Feb., 1936).—Sydney (N.S.W.) is about to expend $30,000,000 in extending its sewerage. At present, of 2000 miles of sewer pipe, all but 60 are of stoneware, and nearly all of the reported failures were in the concrete. The extra cost of stoneware is 7% over concrete, but engineers state that stoneware is practically imperishable. H.H.S.

PATENTS

Brick veneer support. E. W. NAVARRE. U. S. 2,034,766, March 24, 1936 (Dec. 13, 1935).

Method of making lightweight aggregate. W. P. STANTON (National Gravelite Corp.). U. S. 2,035,845, March 31, 1936 (Oct. 8, 1935).—The method of manufacturing lightweight aggregate for concrete comprises sub-dividing an argillaceous material, separating the subdivided material into portions having particles of different ranges of size, separately heating the portions to their respective temperatures of softening and vesiculation to impart to each portion a desired degree of strength and vesicularity, and maintaining the constituent particles of each portion individually distinct and in substantially constant relative movement throughout the heat treatment.

Refractories

Cements in refractory masonry. MARCEL LÉPINGLE. *Verre & Silicates Ind.*, **7** [3] 27–29; [4] 38–41; [5] 50–52 (1936).—Different types of cements, their behavior on firing, determination of the softening curve with heat under constant weight, and examples from practice are discussed. M.V.C.

Chemistry of high temperatures. OTTO RUFF. *Chim. & Ind.*, **35** [2] 255–66 (1936).—Different aspects and

practical applications of the chemistry of high temperatures are reviewed: (1) Displacement of molecules and recrystallizations (phenomena studied notably by Tammann); description of the procedure permitting nonplastic refractory substances to be molded; applications to graphite. (2) Viscous fusion and softening; manufacture of hard metals; preparation of refractory ceramic objects free from pores. (3) Fusion; determination of the fusing point of oxides; objects made of carbides, nitrides, and borides; fusion of graphite. (4) Volatilization; spring-balance method for the determination of the beginning of boiling of liquid metals; effusion process of Knudsen; condensation process; process of crystal growth. (5) Activation of gas. M.V.C.

Classification of insulating refractories. E. J. Bognar. *Refrac. Jour.*, **12** [2] 76 (1936); see *Ceram. Abs.*, **15** [1] 21 (1936). M.C.S.

Control of temperature of plastic flow and the coefficients of elasticity and thermal expansion of refractory bodies. R. J. Montgomery and E. G. Couch, Jr. Read before Can. Ceram. Soc., Toronto, Feb., 1936; abstracted in *Can. Chem. Met.*, **20** [3] 67–68 (1936). E.J.V.

Destruction of silica brick in tank furnaces. A. S. Ruga and M. D. Tamarina. *Keram. i Steklo*, **11** [12] 19–23 (1935).—The basic factor producing the rapid destruction of silica brick of the crown and burners is the chemical inter-reaction of the brick with the vapors from the batch. Analysis of the destroyed parts of brick show the lowering of SiO_2 and a marked increase in Na_2O, Al_2O_3, and Fe_2O_3 contents; some SO_3 was also detected. M.V.C.

Deterioration of coke-oven doors. Editorial. *Coal Carbonization*, **2** [3] 49 (1936).—Attention is called to the work of C. Köppel and of A. T. Green, showing that the decomposition of carbon monoxide by iron oxides and the consequent deposition of carbon in coke-oven door refractories is a more serious disintegrating factor than are rapid temperature changes. Iron in the form of silicates is relatively innocuous. The only real test is subjection of the specimen to CO. For very hot ovens semiacid brick, which have been calcined above the quartz inversion point, are suggested. Thermal expansion should be low, stability to rapid temperature fluctuations should be high, and iron in oxide, metallic, or carbide forms should be absent. Certain gaseous hydrocarbons also have a similar disintegrating action as has CO. G.T.

Direct production of steel. Editorial. *Indian Eng.*, **92** [11] 211 (1932).—A new method of producing rustless iron and steel devised by Gustav Anderson of Skandinavisk Direct Stal A. S. of Larvik is described. A.P.S.

Effect of roasting on solubility of alunite. J. R. Adams. *Ind. Eng. Chem.*, **27** [7] 780–82 (1935).—Solubilities as influenced by roasting temperatures are of fundamental importance in the search for extraction methods that yield high-grade alumina. Experiments indicate that the optimum roasting temperature lies in the region of 500° to 600°C. Illustrated with curves. F.G.H.

Elimination of errors due to irregularities of the heating zone in determining refractoriness. V. A. Lebedev. *Zavodskaya Lab.*, **4** [10] 1282–84 (1935).—A special device is used to rotate the stand on which the cones are placed, thus permitting a regular heating from all sides. P.B. & E.S.

Everyday application of insulating fire brick. M. J. Terman. *Ind. Heating*, **3** [1] 31–33; [2] 121–24, 126 (1936).—The advantages of insulating fire brick over heavy refractories as lining material in the metallurgical and ceramic industries are pointed out. They can be used up to 2950°F except in places where mechanical abrasion and slagging conditions prevail. Tables of physical and mechanical properties are given, and a few installations with operating data are described. M.H.

Flow of ceramic bodies at elevated temperatures. F. H. Norton. *Jour. Amer. Ceram. Soc.*, **19** [5] 129–34 (1936).

Mortars for laying grog brick: I. G. G. Feldgandler. *Ogneuporui*, **3** [7] 524–30 (1935). **II, Influence of additions.** *Ibid.*, [8] 574–81.—By adding soluble glass, the refractoriness, density, and linear shrinkage decrease, and the permeability to air (not in the case of mortars with sand) and the resistance to rupture increase. Portland cement can be added where high strength combined with moderate air permeability is required. Additions of diatomaceous earth decrease the density and strength of the mortar and lower its refractoriness and load capacity. P.B. & E.S.

Production of chromite refractories. A. S. Frenkel and A. S. Berezhnoĭ. *Ogneuporui*, **3** [6] 449–55 (1935).—Mixtures of chromite with quartzite, clay from different deposits, alumina, soluble glass, soda, lime, magnesite, dolomite, magnesia and quartzite in the proportion of $2MgO:SiO_2$, magnesia and alumina in the proportion of $MgO:Al_2O_3$, natural serpentine, and other materials were investigated as to their refractoriness. Chromite had the following chemical composition: SiO_2 3.40, Al_2O_3 14.75, Cr_2O_3 42.0, FeO 22.92, CaO 0.58, and MgO 14.63%. High-refractory mixtures with quartzite can be obtained with 0 to 15% and 87 to 100% chromite. With 0 to 44% alumina the refractoriness did not fall under cone 37. Soluble glass (20%) and soda lower it to cone 16. With up to 20% CaO, 15% MgO, and 20% dolomite it was over cone 37. With serpentine (over 24%) it falls to cone 18. If clay, kaolin, aluminium oxide and its salts, soluble glass, etc., are used, low-melting glasses and silicates are formed with the magnesia silicates present. A binding mass of fosterite type was taken, amounting to 20% after firing. The mass had the following granulometric composition: 1 to 2 mm. 6%, 0.5 to 1 mm. 8%, 0.2 to 0.5 mm. 24%, and under 0.2 mm. 62%. Samples were pressed at 300 kg./cm.^{2}, fired at 1650° for 6 to 6.3 hr., and cooled for 24 hr. The brick obtained was sintered; the mechanical strength was from 350 to 500 kg./cm.^{2}, water absorption 5.1 to 6.2%, apparent porosity 17.4 to 20.9%, volume porosity 17.4 to 20.9%, volume weight 3.2 to 3.4, specific weight 4.1 to 4.2, refractoriness above cone 39, beginning of deformation under load of 2 kg./cm.^{2} at 1570° to 1595° 2%, and collapse at 1620°. P.B. & E.S.

Production of steel casting nozzles with high alumina content. V. Trubenkov. *Ogneuporui*, **3** [6] 414–19 (1935).—By adding grog from clay high in Al_2O_3 to the clay usually used, the alumina content of the charge was increased to 39.95 to 40.25% as compared to the usual 34.92%. The nozzles were fired at 1435°C. The high-

aluminate nozzles had a mechanical strength of 190.0 to 201.7 kg./cm.^{2} against 187.9 with the usual clay. They gave better service. P.B. & E.S.

Properties of magnesite brick. P. P. BUDNIKOFF AND D. A. NIRENSHTEIN. *Ogneuporui*, **3** [6] 437–49 (1935).—The authors analyze the universal literature on the effect of iron oxide in magnesite brick and its influence on deformation under load at high temperatures. Investigations demonstrate that fluxes in magnesite lead to a considerable increase in deformation under load at high temperatures. On account of its catalytic action on the formation of periclase by forming magnesioferrite ($MgO \cdot Fe_2O_3$), Fe_2O_3 is desirable in small quantities (not more than 2 to 3.5%); the increase of the iron oxide content in magnesites containing natural admixtures, together with an increased content of other fluxes, leads to the formation of a series of more low-fusible compounds ($2MgO \cdot SiO_2$, $FeO \cdot SiO_2$, $2FeO \cdot SiO_2$, etc.), resulting in considerable increase in deformation. The composition of Satka magnesite (Ural) is MgO 46.2, CaO 0.9, Fe_2O_3 1.4, Al_2O_3 0.75, SiO_2 1.0, and CO_2 49.88%. This assures the obtaining of high-grade magnesite brick, possessing a high temperature of deformation (not under 1500 to 1550°, 4% at 1700 to 1710° and higher) and other high characteristics. Its chemical composition varies as follows: MgO 92.0 to 93.70, CaO 1.27 to 2.1, SiO_2 1.79 to 2.05, Al_2O_3 0.42 to 0.71, Fe_2O_3 2.16 to 3.09%; refractoriness over 2000°C. Thirteen tables characterizing magnesite refractories from the most important magnesite deposits are appended. P.B. & E.S.

Properties and tests of modern clay flux blocks. GEORGE A. LOOMIS. *Glass Ind.*, **17** [4] 122–23 (1936).—The determination of porosity, shrinkage, or permanent expansion on reheating, pyrometric cone equivalent, chemical and petrographic analyses, and some modified form of heat-shock test are desirable and usually advisable in testing flux blocks, but none can be substituted for direct determination of resistance to corrosion. The only reliable test of corrosion of tank blocks is in a miniature tank employing a commercial glass batch or one modified to increase its corrosive action. When test blocks do not differ greatly in resistance to corrosion, the test must be run continuously for several weeks to obtain reliable results. Test blocks form the side walls of a circular tank which revolves continuously during the test in the tank used by L. A detailed description is given. Illustrated. E.J.V.

Pure alumina ware. THERMAL SYNDICATE, LTD. *Jour. Sci. Instruments*, **13** [1] 29–30 (1936).—The high-porosity laboratory ware is said to be resistant to heat shock (1000°C to room temperature suddenly without breaking); the low-porosity ware is less resistant. Its properties are as follows: composition over 99.9% Al_2O_3; fusion point above 1960°C (Seger cone 41); specific gravity $D_4^{20°} \times 3.97$ (true), 3.8 (apparent, allowing for moisture); hardness 9, Mohs' scale; linear expansion 8×10^{-6} (20° to 1750°C); electrical resistance, higher at 800°C than quartz glass or porcelain. Reducing gases have no effect even at high temperatures. Acids and alkalis have no action at ordinary temperatures. Metals can be fused in Al_2O_3. One photograph. J.L.G.

Refractory minerals and materials. Thorium dioxide. S. I. PERKAL. *Refrac. Jour.*, **11** [8] 407 (1935).—Thorium dioxide is a rare refractory oxide with a melting point of 3050 ± 25°C, a specific gravity of 9.3 to 9.7, and a linear coefficient of expansion of 9.3×10^{-6} (25° to 800°C). It is used largely in the manufacture of incandescent gas mantles and as constituent in the mixture of rare elements in making the filaments for Nernst lamps. **Andalusite.** ANON. *Ibid.*, [9] 451.—A brief discussion of the occurrence, properties, and uses of andalusite is given. **Beryllium oxide.** FELIX SINGER. *Ibid.*, [11] 567.—Beryllium oxide is a white powder with a specific gravity of 3 and a melting point of 2450°C. As it is an excellent heat conductor, it is not sensitive to sudden temperature changes. **Rutile.** ANON. *Ibid.*, **12** [1] 36 (1936).—The occurrence, properties, and uses of rutile are described. **Syenite.** ANON. *Ibid.*, [2] 90. **Siemensite.** FELIX SINGER. *Ibid.*, [3] 149; for previous abstracts see *Ceram. Abs.*, **12** [2] 67 (1933); **14** [7] 167 (1935); **15** [2] 65 (1936) M.C.S.

Stability of brick with a high grog content. K. G. LUPIN. *Keram. i Steklo*, **11** [11] 21–22 (1935).—Tank-furnace brick with a high grog content (85% grog) produced by pneumatic stamping showed a much greater superiority as to resistance to molten glass and durability than brick manufactured by other methods. Cases from practice are described. M.V.C.

Testing silica-aluminous refractory materials at high temperatures. B. LONG. *Céramique*, **38** [571] 219–24 (1935).—L. uses a small thermostatically controlled electric furnace for measuring the load-bearing properties of refractory materials at high temperatures. He finds that the failing curve under pressure at 1500°C (1) gives evidence of the total porosity and (2) furnishes, under the name of coefficient of apparent viscosity, a measure of its value in practice. See also *Ceram. Abs.*, **15** [1] 23 (1936). M.H.B.

PATENTS

Boiler-furnace wall. W. A. JONES (Fuller Lehigh Co.). U. S. 2,034,677, March 17, 1936 (March 18, 1930; renewed Sept. 1, 1934).

Manufacture of granular aluminum hydroxide. S. S. SVENDSEN (Clay Reduction Co.). U. S. 2,036,508, April 7, 1936 (Aug. 28, 1931). The method of producing porous, coarse granular aluminum hydroxide from a crystalline aluminum salt containing water of crystallization comprises subjecting crystals of the salt to the action of ammonia, simultaneously removing water liberated in the reaction, and simultaneously cooling the reaction mixture to a temperature such that unreacted salt is maintained in crystal form.

Method of making chromite refractories. G. E. SEIL (E. J. Lavino and Co.). U. S. 2,037,600, April 14, 1936 (Oct. 28, 1932, Dec. 5, 1935). The process of making a chromite refractory from natural chrome ore comprises grinding chrome ore to produce relatively coarse granules, treating dead-burned crystallized magnesium oxide to convert it to finely divided form, and mixing the relatively coarse ground chrome ore with the finely divided magnesium oxide in an amount greater than 12½% of the total weight of the mix but insufficient to decompose the chromite spinel of the ore and thereby forming a refractory

composition characterized, after firing, by a substantially higher softening point than a similar refractory not treated with the magnesium oxide.

Refractory brick construction. J. B. TRACY (General Refractories Co.). U. S. 2,037,280 and 2,037,290, April 14, 1936 (May 28, 1934).

Refractory clay articles, refractory patching cements, processes of forming ceramic refractories of the argillaceous type, and processes of bonding green argillaceous refractory ware. NATIONAL ALUMINATE CORP. Brit. 444,323, April 1, 1936 (Sept. 25, 1933).

Terra Cotta

Manufacture of salt-glazed stoneware pipes and fittings. A. COULHON. *Rev. mat. constr. trav. pub.*, No. 313, pp. 154–59B; No. 314, pp. 170–72B; No. 315, pp. 189–90B (1935); No. 316, pp. 12–14B; No. 317, pp. 25–28B (1936). **VII.** Translated in *Brit. Clayworker*, **44** [524] 250–51 (1935).—Mixtures suitable for pipe manufacture are given and discussed. **VIII.** *Ibid.*, [525] 301–302 (1936).—Machinery for the manufacture of the clay products, methods of preparation of batches, and manufacture by the plastic process are discussed. **IX.** *Ibid.*, [526] 324–25.—The manufacture of pipes by the plastic process is dealt with. The shredder, grinding, conveyers, soaking, grinding of the grog, and making up the clay mixtures are discussed. For Parts **IV–VI** see *Ceram. Abs.*, **15** [3] 96 (1936). M.V.C. + R.A.H.

BOOK

Methods for testing acid-stable materials. S. A. ZHIKHAREVICH AND D. I. KIVIN. *Ukrain. Nauchno-Issled. Inst. Ogneuporov and Kislotouporov.*, No. 32, 113 pp. (1935).—As a result of the experimental work and of a comparison of the methods used, a series of rational methods were developed for determining the solubility of bodies in acids and for measuring the density of ceramic stoneware bodies and natural acid-resisting materials. The method for measuring the solubility of bodies in acids is based on the method of Kallauner-Barta supplemented with the following operations: (*a*) dissolving of the tiny sulfuric crystals by heating them on a water bath; (*b*) neutralization of "acid" grain (grains treated with H_2SO_4) in the presence of methyl orange; and (*c*) neutralization of "alkali" grains (grains treated with soda ash) in the presence of phenolphthalein. M. V. CONDOIDE

PATENTS

Arrangement of the reaction chamber for the treatment of material. WALTHER KANGRO AND AGNES LINDNER. U. S. 2,037,241, April 14, 1936 (Dec. 1, 1932). A reaction furnace for treating materials by means of a heated active gas comprises walls of a normal ceramic substance defining a reaction chamber.

Ornamented ceramic structure. E. C. GAERTNER AND G. W. SHOEMAKER. U. S. 2,036,131, March 31, 1936 (Aug. 18, 1934).

Whiteware

Artificial teeth of ceramic material. R. POHL. *Keram. Rundschau*, **42** [33] 408–409 (1934).—Porcelain teeth and enameled or painted teeth have fallen into disuse. The only satisfactory artificial tooth is a mineral one. The mix contains 75 feldspar, 22 quartz, and 3 kaolin. After very fine grinding and passing through a 10,000-mesh sieve, finely ground metal-oxide frit is added and thoroughly mixed. The coloring oxides are CoO, NiO, CuO, Cr_2O_3, and TiO_2. Each tooth has two tints. An addition of 3% water containing rice starch is made. After further mixing, the mass is forced into bronze molds, visible parts of teeth remaining outside. These parts are cut obliquely and a "cutting" mass is fixed by a spatula; this gives a third color. The mold usually holds 12 teeth. After pressing, it is heated to 120°C. The starch gives sufficient hardness to allow the teeth being taken off and cleaned. They are fired in a 3-story muffle kiln. The temperatures of the muffles are 120°, 900°, and 1390°C, each heating lasting approximately 5 min. Investigation on underfiring and bubbles was made. It is anticipated that in the future entire sets will be manufactured instead of individual teeth. F.E.V.

Pottery manufacturing problems. ANON. *Pottery Gaz.*, **61** [706] 568–76 (1936).—A discussion of problems encountered in pottery manufacturing, covering "whirlers," peeling of dry glaze, fineness of glaze grinding, specked dishes, casting *vs.* jiggering, white wall-tile body composition, warming of body slip, and rubber-lined cylinders for grinding glazes, is presented. E.J.V.

Pyrophyllite in wall-tile bodies. IRA E. SPROAT. *Jour. Amer. Ceram. Soc.*, **19** [5] 135–42 (1936).

BOOKS

Italian Porcelains. (Le Porcellane Italiane). GIUSEPPE MORAZZONI. Edit. Tumminelli & C., Milan-Rome, 1935. 273 pp., 192 pp. of illustrations. This is the first complete, exhaustive treatment of the history of the manufacture of Italian porcelain from the 15th Century to the present time. Its appearance coincides with the bicentenary of the Factory of Doccia. The work testifies to the extensive study and research of M. in assembling and organizing material from all sources; much heretofore unpublished data are given. A magnificent collection of several hundred photographs of rare museum pieces comprises practically one half the book. M. V. CONDOIDE

Mariupol Porcelain Combine. Compiled on the ground of the technical project by M. L. SHAPIRO. Edited by A. M. VLASOV. Published by the Administration of the Construction of the Mariupol Porcelain Combine. Moscow, 1934. 88 pp. The book gives the present state and problems of development of the porcelain industry in the U.S.S.R. and a detailed description of the proposed Mariupol combine with plans, illustrations, detailed technical and economical data, etc. P.B. & E.S

Rapid methods for controlling quality of porcelain and whiteware products. S. A. Berzon. Ukrgizlegprom, Kharkov, 1934. 51 pp. Price 2R. The methods discussed deal with (1) appearance of ware, (2) mechanical durability, (3) chemical resistance, (4) thermal stability, and (5) standard sizes. M. V. Condoide

PATENTS

Bidet attachment for water closets. Ippolito Salvoni (Riccardo Salmona and E. Q. Jackson). U. S. 2,036,985, April 7, 1936 (March 21, 1935; renewed Jan. 31, 1936).

Combined toilet and bidet. Ippolito Salvoni (Riccardo Salmona and E. Q. Jackson). U. S. 2,036,984, April 7, 1936 (Feb. 11, 1935; renewed Jan. 31, 1936).

Pouring arrangement of teapots, coffeepots, jugs, etc. Tom Cheetham and W. E. Goodwin (William Newton Bate). U. S. 2,036,120, March 31, 1936 (Dec. 26, 1935). A combined pouring spout and drip catcher including a spout has an exteriorly substantially flat front face extending downwardly of the spout from a point spaced from the upper extremity of the spout, the spout having its front wall thickened at the lower end of the flat portion to provide a boss having its upper face extending forwardly and downwardly from the lower end of the flat portion of the spout, a wall having a front portion extending upwardly from the lower end of the upper face and having side portions connecting the front portion of the wall with the spout at the sides of its flat front face, and a lip extending between the side portions of the wall downwardly from the front portion of the wall, the lip being spaced from the spout and having its lower part spaced from the front portion of the wall.

Siphon breaker for water closets. R. A. Brooks. U. S. 2,034,173, March 17, 1936 (May 28, 1931).

Equipment and Apparatus

Application of absorption measurements in a simplified apparatus of Jamin with polarized rays. P. Barchewitz. *Compt. rend.*, **202** [4] 300–301 (1936).—The modified interferometer eliminates the half-wave plate and can be used in the ultra-violet by replacing the mica plate by a quartz plate. M.H.

Combined recording microphotometer, densitometer, and comparator. P. A. Leighton, S. Smith, and F. C. Henson. *Rev. Sci. Instruments*, **5** [12] 431–34 (1934).—An instrument which may be used as a registering microphotometer, a direct-reading densitometer, and a comparator is described. It utilizes a radiometer as the light-sensitive device. Records are taken on 4- x 10-in. photographic plates, direct readings on a 50-cm. scale, and intervals are read by means of a 10-in. comparator screw. H.E.S.

Controlling the expulsion of moisture ("smoking") during the firing of heavy products and determining the dew-point. B. S. *Rev. mat. constr. trav. pub.*, No. 317, pp. 17–19B (1936).—Kiln gas contains a large quantity of water-vapor, and its condensation on the cooler surface of the ware is the principal cause of firing defects when followed by a sudden rise in temperature (formation of sulfuric acid which in turn forms soluble salts in reacting with the minerals of the clay). How this may be controlled and the determination of the dew-point are explained. M.V.C.

Dielectric constant of mineral powders. Joseph L. Rosenholtz and Dudley T. Smith. *Amer. Mineralogist*, **21** [2] 115–20 (1936).—Data are given for the dielectric constants of 160 mineral powders determined by the use of an alternating current of 60 cycles at 220 volts. While the values given are not specific enough to be used alone for diagnostic purposes, they are useful in the separation of mixed mineral powders and give the correct order of magnitude for work of this kind. When there is an appreciable difference between the dielectric constants of two or more minerals, their separation from a mixed powder can be accomplished in a short time. The minerals can be separated, one by one, by altering the dielectric constant of the liquid in which the mixture is immersed. F.J.Z.

Dielectric power factor measurements at audio- and radio-frequencies. G. M. L. Sommerman. *Rev. Sci. Instruments*, **5** [10] 341–45 (1934).—A description of sensitive and accurate apparatus for measuring the power factor of dielectrics in the frequency range 60 to 7,200,000 c.p.s. is given. A Wien bridge with Wagner ground for the direct measurement of both power factor and frequency in the range 60 to 10,000 c.p.s. is described. The operation of the resonance-substitution method is discussed for the frequency range 10,000 to 7,200,000 c.p.s. A measuring cell for use with these circuits and with d.c.-measuring circuits is described. It is shown that power factor-frequency data furnish a delicate method of tracing dispersion phenomena and are useful where the concentration or electric moment of material producing dispersion is small. H.E.S.

Effect of degree of vacuum and general forming problems. T. B. McAvoy, Jr. *Proc. Nat. Paving Brick Assn.*, p. 71 (1935); for abstract see *Ceram. Abs.*, **14** [8] 196 (1935). M.C.S.

Electric furnace in continuous manufacturing operations. G. Simon. *Elektrowärme*, **6** [2] 59–64 (1936).—Selection of furnace type, dimensions, and transport devices for the material is discussed, and examples of metallurgical and ceramic furnaces are described. M.H.

Endless chain haulage gears in quarries and brickworks. A. C. Farren. *Mech. Handling*, **20** [5] 151–54 (1933).—The calculation of chain pull and power requirements and the design of track, chain, and wagon details for simple endless chain haulage gears are discussed. J.C.C.

Evaporation technic for highly refractory substances. H. M. O'Bryan. *Rev. Sci. Instruments*, **5** [3] 125–26 (1934).—Platinum, boron, molybdenum, quartz, and other substances have been evaporated in vacuum from a crucible heated by bombardment with electrons at 4000 volts from a tungsten filament. A small, pure graphite

crucible was heated to its melting point (about 3500°C) by 100 milliamperes of electron current. Most elements will alloy with tantalum or molybdenum crucibles and therefore a graphite cup is usually preferable. Low melting point substances which would easily alloy with a tungsten filament can be readily handled by this method, which has been used in the preparation of X-ray target surfaces, small mirrors, and absorbing films. H.E.S.

Evenness tester. I. J. Saxl. *Rev. Sci. Instruments*, **5** [10] 365–66 (1934).—An evenness tester is illustrated and discussed which shows directly the size as well as the percentage deviation therefrom. H.E.S.

Gas-conversion factors. H. S. Nutting. *Ind. Eng. Chem.*, **27** [7] 820 (1935).—A chart is presented for determining gas-conversion factors for the reduction of the volume of a gas saturated with water-vapor to standard conditions. F.G.H.

High-pressure Wilson expansion chamber. L. M. Mott-Smith. *Rev. Sci. Instruments*, **5** [10] 346–50 (1934).—A new expansion chamber is described and illustrated in which the pressure of the gas in the working chamber can be increased to about 15 atmospheres. H.E.S.

Immersion liquids of high refractive index. C. D. West. *Amer. Mineralogist*, **21** [4] 245–49 (1936).—A set of immersion liquids for the refractive index range 1.78 to 2.06, made up of the components phosphorus, sulfur, and methylene iodide, is described. From five months' experience with the liquids it is concluded that they are practically stable and safe to use with proper precautions. F.J.Z.

Improved specific gravity balance. Paul F. Kerr. *Amer. Mineralogist*, **21** [2] 121–24 (1936).—A balance, with a weighing range from 0 to 150 carats (0 to 30 g.), which combines the accuracy of determination possible with a beam balance with the speed attainable with a Jolly balance, has been developed for the determination of specific gravity of crystals, small masses of minerals, gem stones, etc. Detailed description of the design and operation are given. F.J.Z.

Machines for the manufacture and preparation of ceramic mixes (porcelain, stoneware, faience). Pierre Renault. *Rev. mat. constr. trav. pub.*, No. 314, pp. 173–75B (1935).—The Erel filter press, with square filters and arrangement for rapid tightening and loosening for improving slips, and a machine (Erel) for working and homogenizing a disk of the mix are described. See *Ceram. Abs.*, **15** [3] 100 (1936). M.V.C.

Materials move by gravity in kyanite plant on North Carolina mountainside. W. E. Trauffer. *Pit & Quarry*, **28** [9] 46–48 (1936).—A detailed description of the kyanite plant of the Celo Mines, Inc., near Burnsville, N. C., is given. Illustrated. E.J.V.

Measuring the thermal expansion of solids. O. Cosmann. *Keram. Rundschau*, **43** [17] 195 (1935).—The Goerz apparatus is not suitable for measuring the expansion of soft solids. The optical set-up is replaced by a measuring clock allowing readings within a range of 10 mm. and an accuracy of 1μ. The test pieces are placed between planes instead of cones. The clock is used until the softening point, which is exactly shown. Sudden or important variations of length are readily measured. The transmission punch shows irregular expansion due to cristobalite effect at about 260°C, as does the pointed pin of the clock at temperatures above 470°C. Corrections are tabulated. From 870° to 1300°C quartz is used. Cooling down as well as heating should be recorded. The clock is suitable for measurements at low temperatures and for investigation of elasticity with respect to temperature. F.E.V.

Mechanical handling in quarries. M. I. Williams-Ellis. *Mech. Handling*, **19** [5] 161–68 (1932).—A survey of mechanical handling appliances employed in quarry work is given. Short descriptions are included of typical cranes, conveyers, overhead runways, bucket-type elevators, screens, feeders, drag-line scrapers, excavators, aerial ropeways, hoists, and haulage gear. J.C.C.

Photoelectric cell increases sensitivity of potentiometer operation. C. J. Tagliabue Mfg. Co. *National Petroleum News*, **28** [11] 42–47 (1936).—This apparatus is available in controller-recorder and controller-indicator types and is especially adapted to heat control. R.W.R.

Photoelectric reflectometer. Richard S. Hunter. *Better Enameling*, **7** [3] 12–13 (1936).—The new types of reflectometers are particularly suited to reflectance measurements of porcelain enamel samples and can be applied to a number of problems of research and control, such as measurement of (1) lightness or reflectance, (2) contrast ratios, opacity, and hiding power, (3) color, color differences, yellowness, and tinting strength, and (4) blackness. A description of its operation is given. Illustrated. See also *Ceram. Abs.*, **14** [2] 45; [11] 286 (1935). E.J.V.

Polarizing microscope in ceramics. J. G. Norval. Read before Can. Ceram. Soc., Toronto, Feb., 1936; abstracted in *Can. Chem. Met.*, **20** [3] 67 (1936). E.J.V.

Porcelain pyrometric tubes. S. A. Ruidalchuk. *Keram. i Steklo*, **11** [11] 22–26 (1935).—Porcelain pyrometric tubes for the protection of thermocouples are discussed, and experiments to determine (1) their mechanical properties, (2) thermal resistance, (3) effect of diameter of the pipe on thermal resistance, (4) temperature of softening and melting, (5) coefficient of expansion, (6) thermal conductivity, and (7) chemical stability are briefly described. The results are tabulated. Directions for using porcelain pyrometric tubes are given. M.V.C.

Preparation of specimens for the measurement of thermal conductivity. J. M. Adams. *Rev. Sci. Instruments*, **5** [7] 250–52 (1934).—A. describes an exactly reproducible method of applying metallic coatings to the surfaces of solid specimens and of imbedding thermocouples precisely at any given depth in the coatings. The method makes possible the complete elimination of the variable discontinuity of temperature (which is always present, to a greater or less degree, in measurements of thermal conductivity) between the specimen and the metallic surfaces in contact with it. A new technic for stripping fine silk-covered wires is described. H.E.S.

Production of high temperatures. G. Ribaud. *Chim. & Ind.*, **35** [1] 3–11 (1936).—Different types of furnaces for high temperatures, their advantages and disadvantages, and their adaptation to several concrete cases are discussed. New aspects of the problem of the production of high temperatures in the laboratory (flame of atomic

hydrogen, induction furnace, and furnace with concentration of heat) are taken up. M.V.C.

Recording dilatometer of high sensitivity. A. GOETZ, J. W. BUCHTA, AND T. L. HO. *Rev. Sci. Instruments*, **5** [12] 428–31 (1934).—A recording dilatometer is illustrated and described which is used to investigate the details of thermal expansion of crystals over small temperature intervals. The instrument has (*a*) high sensitivity, *i.e.*, an amplification of 10^3 to 10^4, which is easily adjustable, (*b*) a high degree of thermal stability of the actual expansion chamber, and (*c*) an arrangement which permits a reproducible change of temperature with time to almost any degree of slowness to avoid the development of thermal gradients due to imperfect isothermal conditions. It is recording, as measurements extend over long time intervals. H.E.S.

Simple constant-level suspension. R. P. JOHNSON AND W. B. NOTTINGHAM. *Rev. Sci. Instruments*, **5** [5] 191–92 (1934).—The usual mountings of sponge rubber or taped springs change level. A simple suspension from a single point, consisting of a 2-ft., 37-mil, steel piano wire and small rubber bands stretched horizontally, has given satisfactory results in localities of severe vibrations. Illustrated. H.E.S.

Steady mercury lamp for use in research. A. L. JOHNSRUD. *Rev. Sci. Instruments*, **5** [11] 408 (1934).—A mercury lamp providing steadiness, not only in intensity, but also in position is described and illustrated. H.E.S.

Studies in filtration: IV, Nature of fluid flow through filter septa and its importance in the filtration equation. B. F. RUTH. *Ind. Eng. Chem.*, **27** [7] 806–16 (1935).—The results of investigations upon fluid flow through a variety of septa are summarized. It is shown that Poiseuille's law governs fluid flow through filter septa under the conditions of pressure and rate of flow ordinarily encountered during filtrations. The proof that flow is viscous throughout the entire filtration cycle constitutes an extremely important contribution to the theory and mathematics of filtration and establishes a firm experimental and theoretical basis for the equations previously developed. Illustrated. For Part III see *Ceram. Abs.*, **15** [5] 161 (1936). F.G.H.

Sulfuric acid hygrometer. A. BLACKIE. *Jour. Sci. Instruments*, **13** [1] 6–9 (1936).—This hygrometer determines the vapor pressure of water-vapor in the air by measuring the change in pressure of a constant volume of air before and after absorption of water-vapor by concentrated sulfuric acid. Construction and use are described. Illustrated. J.L.G.

BOOKS

Air Conditioning and Engineering. Edited by the AMERICAN BLOWER CORP., 1935. 691 pp. Price $5.00. Reviewed in *West. Soc. Engrs. Bull.*, **6** [33] 4 (1935).—The importance of the conditioning and mechanical movement of air for the health and happiness of human beings and for efficiency of production in industry is being recognized. This treatise on the technic of the subject has been prepared by a staff of engineering specialists with the object of collecting in one volume, conveniently arranged for ready reference, the data and experience that have accumulated on the subject. The text includes fundamental principles, laws, and tables determined experimentally or mathematically, sample calculations in considerable detail, comprehensive information relating to dimensions and capacities, and a compilation of application data based on the experience of the authors, their predecessors, and contemporary engineers. All subjects are treated in a practical manner, and a mass of invaluable information is presented. Three hundred thirty-two pages are devoted to apparatus and equipment used in connection with air conditioning. Illustrated.

Physicochemical principles of the technology of colloidal graphite suspensions. L. V. LYUTIN. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Mineral. Suir'ya*, No. 73, 43 pp. (1935).—The basic factors determining the aggregative and kinetic stability of suspensions and the conditions of formation and destruction of aggregative stable graphite suspensions in watery and nonwatery media are discussed in detail. M. V. CONDOIDE

PATENTS

Apparatus for analyzing finely divided materials for size. H. E. T. HAULTAIN. U. S. 2,034,185, March 17, 1936 (July 5, 1933).

Apparatus for handling brick. B. F. FITCH (Motor Terminals Co.). U. S. 2,034,722, March 24, 1936 (June 9, 1931).

Apparatus for making one-piece insulators. A. G. BENARD (Locke Insulator Corp.). U. S. 2,034,707, March 24, 1936 (Oct. 24, 1929).

Combined grinding and separating apparatus for granular substances. A. B. HELBIG (V. B. Reichwald). U. S. 2,034,981, March 24, 1936 (Dec. 16, 1933).

Friction wheel spindle press for producing ceramic tile. ALFRED FRANKE. U. S. 2,036,129, March 31, 1936 (Oct. 4, 1935).

Methods of making ceramic bodies. JENAER GLASWERK SCHOTT & GEN. Brit. 444,532, April 1, 1936 (Aug. 1, 1934).

Processes for the manufacture of ceramic products, products resulting from them, and their applications. J. G. A. LEFRANC. Brit. 443,865, March 18, 1936 (Feb. 6, 1934).

Pyrometric device. H. B. HENDERSON AND E. O. HENDERSON. U. S. 2,028,507, Jan. 21, 1936 (April 30, 1935).

Rotary kiln. C. S. GLENN (Mathieson Alkali Works, Inc.). U. S. 2,034,180, March 17, 1936 (May 27, 1935).

Kilns, Furnaces, Fuels, and Combustion

Balance of combustion. A. R. LEYE. *Feuerungstechnik*, **23** [9] 102–105 (1935).—To estimate the character of combustion more exactly, a balance of combustion must be established. This rests on the comparison of the real content in CO_2, CO, and O_2 to their maximum value. The following relation exists between these 3 ratios: $\frac{CO_2}{CO_{2max}} + \frac{CO}{CO_{max}} + \frac{O_2}{O_{2max}} = 1$. The 3 ratios are shown on the triangular diagram of Gibbs by a common point; accord-

ing to its position the character of the combustion can be estimated. According to these ratios, the excess air can be estimated; it is possible to trace, for a given fuel, the lines of the excess of constant air on the diagram. M.V.C.

Continuous tunnel furnace for ceramic firing with complete recuperation. E. DAMOUR. *Céramique*, **38** [572] 235–45 (1935).—D. discusses complete recuperation in tunnel kilns. See also *Ceram. Abs.*, **15** [1] 34 (1936). M.H.B.

Controlling the rate of heating. A. M. STEEVER AND L. A. LINDBERG. *Ind. Heating*, **3** [1] 51–54 (1936).—The importance of adjusting the proper rate of heating to the nature of the material to be heated is stressed. The undesirable effects of thermal lag in temperature-measuring instruments are explained, and methods of control to overcome them are discussed. M.H.

Experimental determination and theoretical calculation of flame temperatures and explosion pressures. BERNARD LEWIS AND GUENTHER VON ELBE. *Phil. Mag.*, **20** [131] 44 (1935).—Theoretical flame temperatures and explosion pressures may now be calculated accurately with the aid of exact band spectroscopic data on specific heats and thermal dissociation. It is shown that experimental and theoretical flame temperatures agree well in many instances. In some cases, experimental values are somewhat higher and in other cases lower than the theoretical values. Various effects are discussed which are responsible for these anomalies, such as time dependency of specific heats and radiation losses. A method is given in an appendix for rigid calculation of theoretical flame temperatures. The work of David and his coworkers is critically reviewed; see "Flame—" *Ceram. Abs.*, **13** [9] 243 (1934). P.T.C.

Gas generators for the ceramic industry. H. GOEHTZ. *Keram. Rundschau*, **43** [21] 239–42; [22] 255–56 (1935).—G. gives an elementary description with a historical outline of gas producers. Since the invention of producers without a grate in 1837, the development may be summarized as follows: the adding of grates for admission and distribution of air, the circular shape of the apparatus, revolving grates (U. S., 1884), the water seal (1900), and the revolving water seal (Kerpely, 1904). Modern producers were introduced in the ceramic industry in 1912. Fundamentals on gasification, gas washing, and special producers for wood are given. Production is inferior to American practice, a producer of 2.60 m. diameter treating 14 to 20 tons of sized bituminous coal in 24 hr. Illustrated. F.E.V.

Natural carbonization. JOHN ROBERTS. *Coal Carbonization*, **2** [3] 57 (1936).—R. reports an investigation of a natural coke formed by igneous intrusion in an Indian mine. Intrusion was 1 to 3 in. thick providing but little heat. The specimen graded from columnar coke with 7% volatile at intrusion to almost unchanged coal 8 in. away. The ignition temperature increased from coal to coke ranging from 429° to 504°C. 4 illustrations, 2 tables. G.T.

Principle of furnace design for anthracite. A. J. JOHNSON. *Ind. Eng. Chem.*, **27** [8] 944–48 (1935).—A new type of furnace that eliminates combustion space over the fire and admits all the air for combustion above, rather than through, the grate is described. Various superior features of performance, as compared with conventional units, include (1) sustained carbon dioxide above 17% for indefinite periods, (2) absence of appreciable carbon monoxide even in the absence of combustion space, (3) operation at full rating with a minimum of draft, (4) uniform combustion over 2- to 5-day periods without manual attention, and (5) clinkerless operation even on low-fusion coals at high rates. The latter property is discussed in detail, and a theory of clinker-proof boiler design is advanced. Illustrated. F.G.H.

Production of high-hydrogen water gas from younger coal cokes. Effects of catalysts. R. E. BREWER AND L. H. RYERSON. *Ind. Eng. Chem.*, **27** [9] 1047–53 (1935).—The influence of fuel and water-gas conversion catalysts upon the rate of hydrogen production from lignite char and steam at 600°, 700°, and 800°C has been studied. The mechanisms of the action of the three fuel catalysts (potassium carbonate, sodium carbonate, or a 60 titanium dioxide to 40 cupric oxide mixture) are considered. Water-gas generated in the usual manner showed increased hydrogen content after passage through water-gas conversion catalysts. Best results were obtained with a 67 magnesia-30 ferric oxide-3 potassium dichromate catalyst used in 48-cm. column length, as 3- to 4-mesh size, in a separate furnace at 500°C. This catalyst retained its activity and ruggedness with repeated use. Study of the volumetric composition of the gas before and after catalytic treatment suggests $CO + H_2O = CO_2 + H_2$ as the main reaction which was induced by the catalyst. See *Ceram. Abs.*, **13** [11] 300 (1934). F.G.H.

Recuperation as applied to industrial furnaces. BENJ. SAMPSON. *Ind. Heating*, **3** [2] 102–104, 120; [3] 161–64 (1936).—The principles of recuperating and utilizing waste heat are explained, and the advantages in economy due to preheating of gas and air in the combustion process, increased production, and better working conditions around a furnace equipped with a recuperator are described. M.H.

Relationship between the specific gravity and ash contents of the coals of Korea and Bokaro: Coals as colloid systems. L. L. FERMOR. *Rec. Geol. Surv. India*, **60** [4] 313–57 (1928).—Working on specimens of Korea and Bokaro coals (Barakar series), F. discovered the following empirical rule connecting the specific gravity and ash contents of any specimen: $a = 100\,(g - k)$, where a is the ash content, g the specific gravity of the specimen, and k the specific gravity constant of ash-free coal (*i.e.*, pure vitrain) for the field. The density-ash curve is linear to about 40% ash and then concave toward the density ordinate. From this it is deduced that these coals must be suspensoid colloid systems in which vitrain acts as the dispersion medium and the ash contents as the disperse phase (suspensoid) with the vegetable detritus contained in the durain present as a second disperse phase (coarse suspension). A.P.S.

Softening of coal by heat. H. C. PORTER. *Ind. Eng. Chem.*, **27** [8] 962–66 (1935).—P. discusses (1) the probable nature and mechanism of the softening and coke-forming process in coal, (2) difficulties inherent in such a heterogeneous and changing material, in making measurements of softening characteristics, (3) some results of efforts to adapt an extrusion method to such measurements with only partial success, and (4) the promising features

of certain other proposed methods which permit separate measurement of a number of contributing factors in the softening phenomenon. Illustrated. F.G.H.

Three hundred years of oil. G. Egloff. *Ind. Eng. Chem.*, **27** [6] 648–55 (1935).—The development and conservation of oil supplies in the U. S. are historically portrayed. F.G.H.

BOOKS AND BULLETIN

High-temperature electric furnaces. Anon. *Hevi Duty Electric Co. Bull.* HD-834; reviewed in *Ind. Eng. Chem., News Ed.*, **12** [21] 402 (1934).—High-temperature furnaces, designed particularly for carbon determinations, are described. They are especially suited for work where temperatures from 2000° to 2300°F are required. These tube furnaces may also be used for standard combustions, pyrometer checking, and other experimental operations requiring temperatures from 1100° to 2300°F. F.G.H.

Manual for the Brick Burner. V. Ya. Yasinskiĭ. ONTI, Leningrad, 1935. 224 pp. The book is designed to give the minimum technical knowledge to the worker occupied in the firing process at brick plants. Raw materials, kilns, the firing process, production control, and organization of work are described. P.B. & E.S.

Textbook of Coal Petrography (Lehrbuch der Kohlenpetrographie). E. Stach. 293 pp., 173 figs. Gebrüder Borntraeger, Berlin, 1935. Price 18 Rm. Briefly reviewed in *Econ. Geol.*, **31** [1] 126 (1936).—S. gives a systematic discussion of coals, the methods employed in studying them, and interpretations of their structural appearance as seen under the microscope. The photomicrographs of coal structure are exceptionally good. A bibliography of 919 entries on the petrography of coal is included. J.L.G.

Geology

Bentonitic magnesian clay mineral from California. W. F. Foshag and A. O. Woodford. *Amer. Mineralogist*, **21** [4] 238–44 (1936).—A bentonitic clay from deposits 3 miles south of Hector, San Bernardino County, Calif., is a hydrous magnesium silicate related to saponite. It is also unusual in its appreciable lithia content (about 1%). Similar magnesian clays are widespread in the Mojave Desert region of Calif. and Nev. F.J.Z.

Chemistry of silicates. Anon. *Verre & Silicates Ind.*, **7** [2] 17–19 (1936).—The chemistry of silicates is shown to be inseparable from the crystallographic study of these substances; knowledge of the structure is at least as important as the chemical formulas if their properties are to be understood. The classification of silicates is possible only because of their crystallographic character. X-ray analysis has permitted further study of the structure of certain substances. M.V.C.

Clay mining in California. Robert Linton. *Mining & Met.*, **17** [352] 198–200 (1936).—Specifications for ceramic clays and methods of classification of clays are listed. California clays of high quality are limited to the Eocene and the Martinez formation. Practically all of the clay mines of Calif. are open-pit operations. One of the striking features is the prevalence of selective mining because of the necessity of carefully controlled blending in the manufacturing plants. Methods used in clay mining are described. Illustrated. E.J.V.

Coefficient of resistance as a function of Reynolds number for solids of various shapes. Hakon Wadell. *Jour. Franklin Inst.*, **217** [4] 459 (1934).—W. attempts to show the usefulness of the degree of true sphericity as an expression for the shape of rock particles. Any radical variation in shape influences the numerical value of the degree of true sphericity and affects the size of the surface area, the size of the largest cross-sectional area, and the degree of circularity of a great number of cross-sections of a solid. These factors largely determine the settling velocity of that solid. The resistance of wholly submerged bodies as a theoretical foundation for determining the coefficient of resistance as a function of Reynolds number for solids of different degrees of sphericity is discussed. The influence of the degree of circularity on the resistance is then shown by graphs constructed on the basis of the available data. Formulas for calculating the coefficient of resistance and Reynolds number are introduced, and their practical value is demonstrated by graphic illustrations. The sedimentological significance and usefulness of the results are discussed. P.T.C.

Constitution, origin, and dehydration of laterite. T. H. Holland. *Geol. Mag.*, **10** [Dec. 4] 59–69 (1903).—H. calls attention to the essential chemical similarity between laterite and bauxite, offers a theory for the formation of laterite in the moist tropics, and suggests an explanation for its spontaneous dehydration. A.P.S.

Fuller's earth of bentonitic origin from Tehachapi, California. Paul F. Kerr and Eugene N. Cameron. *Amer. Mineralogist*, **21** [4] 230–37 (1936).—A commercial deposit of clay having the natural decolorizing properties of fuller's earth occurs near Tehachapi, Kern County, Calif. The clay is essentially a mixture of montmorillonite and a zeolite, probably heulandite. Although commercially a fuller's earth, study of thin-sections demonstrates that the clay has been derived from volcanic ash by alteration, and according to the petrographic definition it has the origin of a bentonite. It seems worth while therefore to record a description of the occurrence of a fuller's earth of bentonitic origin. F.J.Z.

Geochemistry of the Urals. E. E. Zakharov and S. A. Yushko. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Mineral. Suir'ya*, No. 75, pp. 1–46 (1935).—The geochemistry of arsenic, lead, antimony, selenium, tellurium, cadmium, and thallium of the Urals is described. M.V.C.

Investigation of the Bakanskaya deposit of opoka (diatomite earth). M. K. Gavrilov. *Tsement*, **3** [7] 34–42 (1935).—The deposit is situated 37 km. from Novorossiĭsk. A petrographical description and chemical characteristics are given. High-grade pozzolanic Portland cement can be obtained by using it as a pozzolanic addition. P.B. & E.S.

Microscopic analysis of opaque minerals. F. L. Still-

WELL. *Jour. Soc. Chem. Ind. Victoria*, **35** [1] 983–86 (1935). H.H.S.

Microscopic methods for determining the composition of pegmatites. D. S. BELYANKIN AND V. D. ONISIMO-YANOVSKIĬ. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Keram.*, No. 46, pp. 26–51 (1935).—These methods can be used both for the raw materials and fired bodies after crushing. They are based on the determination of the mineral content composing pegmatite by determining the mineral fractions present in the preparations of the crushed materials. Details of procedure are given. M.V.C.

Mineralization of the Virginia titanium deposits. CLARENCE S. ROSS. *Amer. Mineralogist*, **21** [3] 143–49 (1936).—The titanium region of Nelson and Amherst Counties, Va., is the world's largest producer of rutile, and also has large supplies of ilmenite. The titanium ores are associated with a feldspathic rock, but they were probably derived from a deep-seated, highly ferromagnesian rock of which only a few highly altered and mineralized apophyses reach the surface. The feldspathic rock was intruded as a mush of crystals and thoroughly granulated during the process. Therefore the relations are those of an anorthosite, although the plagioclase is andesine, rather than labradorite. The titanium ores occur as disseminations in the feldspathic rock and as dike or vein-like lenses which are largely confined to this rock. Both types of ore were deposited by invading solutions, as they were formed after the intrusion and granulation of the feldspathic rock. A group of associated secondary silicates shows that the introduced materials were titanium, ferric iron, magnesium, and very minor amounts of silica and alkalis. The simple chemical composition of the replaced feldspathic rock and the small number of introduced elements presents an unusually favorable opportunity for the study of the chemistry of mineralization. Near feeding channels, a restricted zone of iron-bearing minerals formed; farther out magnesian minerals and iron-free rutile were deposited, and almost throughout the granulated feldspar rock important mineral changes occurred without marked transfer of minerals. F.J.Z.

Nizhnebakanskaya deposit of opoka (diatomite earth). DUBISSA-KRATCHAK. *Tzement*, **3** [7] 32–34 (1935). P.B. & E.S.

Petrographic characteristics of some Ural rocks as raw materials for the ceramic industry. D. S. BELYANKIN AND V. D. ONISIMO-YANOVSKIĬ. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Keram.*, No. 46, pp. 70–76 (1935).—The large deposits of lestivarite, porphyry, and plagioclasite are described. The qualitative and quantitative characteristics of the mineralogical composition of these rocks are discussed. They have a high feldspar content (from 67.1 to 97.8%) and a low Fe_2O_3 content (1.60 to 0.23%). M.V.C.

Quantitative determination of cadmium, antimony, lead, arsenic, selenium, and tellurium in the Ural copper zinc deposits. S. V. KHOVANSKIĬ. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Mineral. Suir'ya*, No. 75, pp. 47–59 (1935). M.V.C.

Semiz-Bugu andalusites. K. N. OZEROV. *Ogneuporui*, **3** [6] 466–74 (1935).—This is the greatest andalusite deposit in the U.S.S.R. (Kazak Aut. S.S.R.). It also contains quartz, biotite, pyrite, pyrophyllite, alunite, and small proportions of other minerals. A general description of the deposit, chemical analyses, and a petrographic description are given. P.B. & E.S.

Spectrophotometric study of smoky quartz. NORA M. MOHLER. *Amer. Mineralogist*, **21** [4] 258–63 (1936).—The absorption curve of smoky quartz was determined from 700 to 200 mμ; this was compared with its absorption after decoloration by heat and exposure to radium and with clear crystalline and fused quartz colored by the same exposure. Some fluorescence effects were noted. All showed maxima at 16,500, 20,000, 25,000, 33,000, 38,000 (wave number per cm.), with increased absorption beyond 42,000. Further irradiation in general simply increased absorption, but fused quartz showed a shift in importance of the bands, with a superposed lavender tint. The similarity in curves of originally smoky and irradiated specimens confirms the theory of radioactive coloration. The change in energy due to the transfer to an electron from an oxygen to a silicon ion is calculated, with possible subsequent changes due to redistribution of such electrons. These changes correspond to amounts of energy indicated by positions of absorption bands. F.J.Z.

Study of a quarry of kaolin-feldspathic sands. RAOUL DE BLOTTEFIÈRE. *Rev. mat. constr. trav. pub.*, No. 316, pp. 1–4B (1936).—B. gives an example of the valuation of a deposit of kaolin feldspathic sands, which should be made before exploitation on a large scale is undertaken. M.V.C.

What is laterite? L. L. FERMOR. *Geol. Mag.*, **8** [Dec. 5] 454, 507, 559 (1901).—An excellent summary and preliminary classification of laterites and lateritoids are given. The word "bauxite" is best applied to those varieties of laterite sufficiently rich in alumina to be used as aluminium ores. A.P.S.

BOOKS AND BULLETINS

Barytes in the Ceded Districts of the Madras Presidency: With Notes on Its Occurrence in Other Parts of India. A. L. COULSON. *Mem. Geol. Surv. India*, **64** [1] 142 pp. (1933). Price Rs 3/14/- or 6s 6d. 5 plates. C. describes in detail the numerous deposits of barytes occurring in the ceded districts of Cuddapah, Anantapur, and Kurnool, refers briefly to all known occurrences in other parts of India including Burma, discusses properties, marketing, and uses of barytes, and gives statistics of production in India, imports into India, values and prices of barytes, and the outlook for Indian barytes. A. P. SOM

Edgar clays for the ceramic industry. ANON. *Edgar Plastic Kaolin Co. Bull.*, No. 3, 13 pp. (Nov., 1933).—A detailed description is given including the chemical analysis and many physical properties of Florida kaolins. Typical formulas using these clays are given for solid cast sanitary ware, drain cast sanitary ware, dinnerware, art ware, wall and floor tile, and many other whiteware products. M.C. SHAW

Kaolin deposits of Ukraine. I. I. MELNIKOV. *Trudui Inst. Prik. Mineralogii*, No. 70, 34 pp. (1935).—The genesis, composition, and properties of various Ukrainian kaolin deposits are described. M.V.C.

Khaidarkan mercury-antimony-fluorite deposits. A. I. Suloev and A. L. Ponomarev. *Trudui Vsesoyuz. Nauchno-Issled. Inst. Mineral. Suir'ya*, No. 71, 77 pp. (1935).—A detailed geologic, petrographic, and mineralogic description is given. M.V.C.

Mineral Industry of the British Empire and Foreign Countries: Lithium. H. M. Stationery Office, London, 1932. Price 6d. Reviewed in *Indian Eng.*, **92** [18] 358 (1932).—The book is a concise summary of the present knowledge of lithium, dealing particularly with the natural sources of the metal, its preparation and uses, together with the world's production and marketing of lithium minerals in addition to a description of their occurrence in both British and foreign countries. The work concludes with a selected and classified bibliography and should prove of considerable service to those interested in this increasingly important metal or its compounds. A.P.S.

Mineral Industry of New Jersey for 1933. Meredith E. Johnson. *N. J. State Dept. Conservation & Development, Geol. Series Bull.*, No. 42, 20 pp. (1935).—This bulletin indicates the trends of production in the various mineral industries throughout the State during 1933. The pottery, iron ore, brick, and tile industries showed a decided increase in production in 1933 over 1932, but the production of stone, sand, and gravel reached its lowest mark since 1908. The production of clay and greensand decreased slightly, but an increase in the value of these products over-shadowed the decrease in production.

M. C. Shaw

PATENTS

Clays and processes for preparing them. Paul Bechtner and W. B. Hirschmann (American Colloid Sales Division, Inc.). U. S. 2,036,617, April 7, 1936 (Sept. 7, 1934). The process of preparing clay for use in forming suspensions consists in determining the critical slaking size range of the clay and sizing the clay so that the particles are largely within the size range.

Process of preparing adsorbent clays. E. M. Slocum. U. S. 2,034,996, March 24, 1936 (May 21, 1934; Jan. 2, 1935).

Chemistry and Physics

Advances in physics during 1934. H. A. Barton (Editor) assisted by E. C. Bingham, R. M. Bozorth, H. Fletcher, K. K. Darrow, J. B. Johnson, and F. K. Richtmyer. *Rev. Sci. Instruments*, **6** [1] 1–3 (1935).—The outstanding discovery in transmutations is the discovery of "induced radioactivity" by the Joliots, and the outstanding subsequent achievement is the transmutation of some 40 elements by neutrons, effected by Fermi and four other Italians and detected by induced radioactivity. The phenomenon signifies that particles impinging on nuclei are producing a transmutation occurring in (at least) two stages: the first stage, presumably happening at the instant of impact, is the formation of a new and unstable nucleus; the second is the spontaneous disintegration of the nucleus, following the first process after a lapse of time varying (for each kind of unstable nucleus) from one case to another according to the law of chance. Aston has effected the mass analysis of nearly all the rare-earth elements, and all but four (Pd, Ir, Pt, Au) of the common elements have already been analyzed, leading to about 250 known kinds of stable atoms. Wilson-chamber photographs of cosmic-ray phenomena show that the paths of charged particles emanate in clusters from pieces of metal placed in or near the chamber, and may result from nuclear explosions due to high-energy photons impinging on the metal. Measurement of the total ionization, due to cosmic rays in the atmosphere at various altitudes and latitudes, indicate a strong proportion of charged particles coming from outer space and suffering deflection by the earth's magnetic field. The theoretical work (of Slater, Brillouin, and others) on the electronic structure of metals has given a more definite picture of the metallic state, particularly as to the electrical conduction. Such characteristics as metallic conductivity depend primarily upon the properties of the separate atoms and their position as to their immediate neighbors in the crystal. New interest has been aroused in the study of "semi-conductors" of heat and electricity by the discovery of the rôle played by dissolved electro-negative elements present in excess of the stoichiometric ratio of the respective elements in inorganic compounds. *E.g.*, the presence of excess oxygen was found to increase the electrical conductivity of Cu_2O and NiO, whereas its presence provoked a decrease in the conductivity of ZnO and CdO. Progress has been rapid in the production and use of heavy water and deuterium. In the field of X-rays there has been considerable activity in determining the widths and shapes of X-ray emission lines and of absorption limits. Spectral measurements have been extended into the extremely short wave-length region and far into the long wave-length region overlapping the short ultra-violet. Much progress has been made in the development of strong, high-voltage sources of penetrating rays for use in hospitals and in research. In optics, improved sources have been devised for ultra-violet spectroscopy. A new branch of physics, "electron optics," deals with the action of axially symmetric electric or magnetic fields upon beams of electrons. The discovery that electrons can be "refracted" by such fields in a manner similar to the action of lenses and prisms has lead to experimental work with three ends in view: (*a*) "lens" systems for Braun or "cathode-ray" tubes, (*b*) "lens" systems for electronic microscopes used in studying films and surfaces, and (*c*) "prisms" for separating electrons of different velocities. In the field of acoustics notable advances have occurred both as to fundamentals and applications. Knudsen has found anomalous absorption of sound in certain mixed atmospheres, the coefficients running as high as 10 to 20 times normal. At high intensities not all sound frequencies are transmitted through air alike, the original sound being distorted. The stereophonic transmission of sound has been further developed, *e.g.*, making an orchestra sound as if it were spread out in space in the same room as a remote audience. Rheology, the science of plastic flow, has progressed in the establishment of standards, definitions, and correlation of methods of measurement. Hardness tests, softening points, penetration tests, ring and ball tests, so-called viscosity measurements of plastic materials, and other empirical measurements of plasticity

now in use are measures of the same property of flow. Current effort in the science is to express them in absolute units. H.E.S.

Chemical formula of malachite. M. Guillot and Geo. Geneslay. *Compt. rend.*, **202** [2] 136–37 (1936).—Recent investigations give for malachite, the green copper carbonate, the composition $8OCu{\cdot}4CO_2{\cdot}5OH_2$ which conforms better to its crystalline structure than the classic formula $2OCu{\cdot}CO_2{\cdot}OH_2$. M.H.

Colorimetric determination of small quantities of sodium. K. L. Malyarov and T. Yudenich. *Zavodskaya Lab.*, **3**, 904–906 (1934).—The Streng reaction (*Z. anal. Chem.*, **25**, 537 (1886)) has been used. The use of uranyl acetate in determining sodium in pit-hole waters has the following advantages as compared with the determination of chlorides: (1) direct determination of sodium in the presence of other elements, (2) rapidity, and (3) the possibility of using the colorimetric method. To obtain a complete precipitation of sodium, a considerable amount of alcohol was introduced into the solution. Washing the precipitate with 50° alcohol according to Barrenschen is not admissible because of its noticeable solving action. Good results can be obtained by washing out with ether and alcohol in the ratio of 2.5:1. The composition of the precipitating solution consists of two solutions: (*A*) 10 parts uranyl acetate, 6 parts 30% acetic acid, and 50 cc. of water; (*B*) 30 parts zinc acetate, 3 parts 30% acetic acid, and 50 cc. of water. The solution takes place in a water bath. After 24 hr. it is filtrated and preserved in a dark place; 1.2 cc. of the reagent is needed to precipitate 1 mg. of sodium. To the solution being investigated is added an equal quantity of 95° alcohol and a sufficient amount of the reagent. After being stirred 10 to 15 min. and standing for 1 hr., the mixture is filtered through a porcelain crucible with a porous bottom. After decantation with alcohol and an ether-alcohol mixture and drying, the precipitate is diluted in hot 2% acetic acid. A small amount of triple acetate corresponding to about 0.1 mg. of sodium is diluted to 100 cc., 1 cc. of 20% $K_4Fe(CN)_6$ solution is added, and the solution obtained is compared with standard solutions in the Dubosc colorimeter. P.B. & E.S.

Crystallography. J. Orcel. *Rev. gén. Sci.*, **47** [3] 68–75 (1936).—A review of recent progress and discoveries in crystallography is given. Determination of crystalline structure by means of X-ray diffraction, the "ideal" crystal and the "real" crystal, and the physical properties of crystals are dealt with. R.W.D.

Decrease of a calcite crystal in an active isotrope medium: note on the corrosion figures in dolomite. L. Royer. *Compt. rend.*, **202** [5] 429–31 (1936).—The attack of different acids on calcite as dependent on the axial directions was studied. The effect is different on the different faces of the crystal. M.H.

Determination of alumina (in silicates) by the aid of the oxalate complex. A. K. Babko. *Zavodskaya Lab.*, **4** [8] 891–93 (1935).—Alumina can be determined by precipitation in the form of $Al(OH)_3$ by alkalis by boiling and using phenolphthalein; the precipitate, after solution in acid, is subjected to titration of the excess acid. To eliminate the hydrolysis of the Al'''-ion, it is bound by the oxalate in the presence of $MgCl_2$. The method is precise and takes 30 to 40 min. The iodometric method can be used. The solution, after treatment with $K_2C_2O_4$, is neutralized and afterward boiled with KI, KIO_3, and $CaCl_2$; after removing the iodine, the residual KIO_3 is determined. The method is more expensive and less precise but can be used if great quantities of MgO and Fe_2O_3 are present. The oxalate can be titrated under boiling with alumina and using methyl red until the complex $K_3[Al(C_2O_4)_3]$ is formed. The method is rapid but not precise. P.B. & E.S.

Developments in microscopy. Francis F. Lucas. *Jour. Franklin Inst.*, **217** [6] 661 (1934).—Improvements in resolution by the use of higher aperture objectives and by decreasing the wave-length of the light used are discussed. The use of the ultra-violet microscope in biology as to the functioning of living cells in response to ultra-violet radiation is touched on. A precision high-power metallographic microscope is described. The mono-bromnaphthalene objective in conjunction with the above microscope is discussed. P.T.C.

Difficulties in the colorimetric determination of p_H values. A. B. Cox. *Jour. Soc. Chem. Ind. Victoria*, **35** [3] 1001–1005 (1935).—The improved technic of the Hellige comparator is described. H.H.S.

Effect of catalyzers on the course of melting of silicate batches. K. A. Krakau, I. O. Ioffe, and A. A. Shakina. *Keram. i Steklo*, **11** [11] 30–34 (1935).—The batch was composed of 61.56 SiO_2, 12.78 Na_2O, 9.30 CaO, and 16.36% CO_2; the catalyzers were Na_2SO_4, NaF, Na_3AsO_4, Na_3PO_4, and Na_2SiF_6. It was found that the introduction of catalyzers, especially $NaAsO_4$ and F compounds, promotes the reaction between the batch components and the formation of silicates. This process is even more accelerated with the use of steam and a catalyzer. NaF, Na_3AsO_4, and Na_2SiF_6 were found to be the most active catalyzers. Illustrated with tables and diagrams. M.V.C.

Flocculation of colloids. A. Boutaric. *Industrie chimique*, **23** [264] 4–9; [265] 93–97 (1936).—In colloidal solutions of metals, oxides, sulfurs, etc., the particles of the colloids have but little affinity for either water or the solvent and consequently yield anhydrous powders or flakes when flocculated. Such substances are termed "suspensoids." Natural colloids (albumen, gum, etc.) swell by adsorption of the solvent; if flocculated, these colloids produce gels which retain much of the solvent; they form a second class named "emulsoids." A small amount of electrolyte generally suffices to cause the flocculation of suspensoids, *e.g.*, 1 g. of NH_4OH will precipitate 1300 g. of Fe_2O_3 (weight after calcination), while emulsoids require a much greater proportion of electrolyte, 10 to 60%. There is no criterion for classifying these two kinds of colloids, for various substances such as alumina, clay, etc., have properties of both kinds. Only extreme terms are differentiated. B. describes successively the phenomena taking place in various flocculating processes of either suspensoids or emulsoids and of mixtures of both colloids. The study covers the following field: (1) general characteristics of flocculation, (2) influence of the concentration and valency of active ions, (3) flocculation caused by certain radiations, (4) peptization, (5) experimental study of flocculation, (6) variation of the duration of the flocculating process in terms of elec-

trolyte concentration, (7) stability of colloidal solutions, (8) influence of hydration, (9) fractional flocculation, reversibility, and (10) reciprocal flocculation, purification of waste water. R.W.D.

Iodometric titration of tin. F. L. Okell and J. Lumsden. *Analyst*, **60** [717] 803–11 (1935).—Low results in stannous titrations are due, not to incomplete exclusion of gaseous O from the titration flask, but to O dissolved in the I solution. This interference is not a constant effect. Removal of Ti is unnecessary if an air-free solution is used for titration. H.H.S.

Lowering superficial energy and hardness (dispersion work of solids) by adsorption layers. P. A. Rebinder and N. A. Kalinovskaya with E. K. Venstrem. *Zhur. Fiz. Khim.*, **5** [2–3] 332–57 (1934). P.B. & E.S.

Measurement of the specific volume of molten diabase. M. Volarovich and Anne Leonteva. *Compt. rend.*, **202** [2] 143–45 (1936).—Diabasic rocks of different origin were studied. Viscosity as a function of temperature was determined, showing a rapid increase at 1150°C. M.H.

Microanalysis. J. G. Pearson. *Chem. Eng. Mining Rev.*, **28** [329] 151–54 (1936).—Microtests are given for Mn, Li, Tl, Ta, Nb, Ti, Th, W, Au, Ce, Co, As, Cu, F, and water. H.H.S.

Piezoelectric and elastic properties of beta-quartz. H. Osterberg and J. W. Cookson. *Jour. Franklin Inst.*, **220** [3] 361 (1935).—By an indirect method it is shown that β-quartz is piezoelectric. The piezoelectric and elastic properties of β-quartz are those which are theoretically characteristic of the hexagonal-holoaxial class. A simple theory of the so-called yz and zx shear modes is verified; the modes are shown both by theory and experiment to exist independently in β-quartz and not in α-quartz; β-quartz would be a valuable piezoelectric substance if it could be rendered stable at room temperatures. P.T.C.

Quick method of determining silica in quartzites, silica brick, and sands. V. Vepritzkaya. *Zavodskaya Lab.*, **4** [12] 1514–15 (1935).—To the sample, fused together with soda and lixiviated by hydrochloric acid of a considerable concentration, a 1% gelatin solution that coagulates and precipitates the silica is added. The concentration of gelatine is of little consequence, but it should not be too high. P.B. & E.S.

Quick methods of chemical analysis of refractory clays and quartzites. V. V. Kraft, V. A. Palouzov, A. Yu. Shapiro, and E. M. Skibina. *Ogneuporui*, **3** [6] 458–63 (1935).—The determination of SiO_2 can be reduced to 5 to 6 hr. by sintering; 4 to 5 times less flux and less acid are needed; the precipitated SiO_2 can be washed out very quickly. The oxyquinoline method, which permits the determination independent of the presence of other elements, is the most expedient and precise method of determining Al_2O_3. The weight method of determining Al_2O_3 takes 2 days as compared with 4 hr. for the volume method. The determination of Fe_2O_3 is most precise if made by volume, *i.e.*, by titration with permanganate or titan trichloride. The latter method is quicker, cheaper, and requires 5 to 6 times less reagent. P.B. & E.S.

Sampling analysis and sample size. M. C. Holmes. *Jour. Franklin Inst.*, **219** [4] 483 (1935).—The theory of sampling as to the functional relationship between sample size, tolerance limits, degree of assurance, and homogeneity is discussed. A theoretical equation correlating the above variables is derived and found to agree well with experimental results. P.T.C.

Stereometric measurements on X-ray photographs. A. Matting. *Giesserei*, **23** [1] 7–11 (1936).—The application of stereoscopic principles in X-ray photography and the determination thereby of the exact location of defects in the material is explained in detail. Some existing apparatus for this purpose is described. M.H.

Technic for the construction of models illustrating the arrangement and packing of atoms in crystals. M. J. Buerger and Robert D. Butler. *Amer. Mineralogist*, **21** [3] 150–72 (1936).—Given the data furnished by the crystal-structure investigator, in general, it is necessary to proceed by a series of distinct steps taken in correct sequence to construct a packing model of the structure. These steps are (1) calculation of the atomic environments in the actual crystal, (2) adjustment of atomic environments to available material, (3) calculation of drilling coördinates, (4) painting the balls, (5) drilling the balls, and (6) assembling the model. Each step is fully described, and examples of application of methods and calculations to the structures of marcasite and sulvanite are given in detail. F.J.Z.

Theory of crystals: I, General equation of the energy of the crystalline lattice. A. F. Kapustinskiĭ. *Zhur. Fiz. Khim.*, **5** [1] 59–63 (1934).—The dependence between Madelung coefficients for different crystalline structures has been established; they are proportional to the amount of ions in the molecule; their lack of identity for different structures is due to the different intervals between ions. K. gives an equation for the calculation of energies of crystalline lattices independent of the structure of the crystal:

$$U = 256.1 \frac{\Sigma_n \cdot \eta_1 \eta_2}{r_k + r_a}$$

where U is amount of energy, η_1 and η_2 are valencies, Σ_n is the amount of ions in the molecule, and $r_k + r_a$ is the sum of effective radii of the cation and anion. **II, Energy of the crystal and thermochemical applications.** A. F. Kapustinskiĭ and B. K. Veselovskiĭ. *Ibid.*, pp. 64–72.—The results obtained by calculating the lattice energies by the formula given in the preceding work are compared with those obtained experimentally, thus confirming the correctness of the formula. A series of examples is given, showing the use of the formula for the calculation of thermal effects (heat of reactions between solids, with the gas phase, heat of solution), and a nomogram for rapid calculations of thermal effects of typical heteropolar crystals is given. **III, Interdependences of energy in morphothropic series of crystals. Polymorphism and isomorphism.** A. F. Kapustinskiĭ. *Ibid.*, pp. 73–76. The interdependence of energy in the limits of morphothropic rows of crystals is investigated, and the radius of the ion of bivalent tin is calculated ($r_{Sn} = 1.04 \pm 0.02$). P.B. & E.S.

Titrations with N/1000 iodine. A. B. Cox. *Jour. Soc. Chem. Ind. Victoria*, **35** [3] 996–1000 (1935).—The technic is described. H.H.S.

Viscosity of fused rocks. M. Volarovich. *Compt. rend.*, **202** [1] 78–80 (1936).—The chemical analysis of several kinds of rocks (basalts, obsidian, andesite, diabase, and artificial glass) is given. Their viscosities (in poises) in the molten state at temperatures from 1100° to 1400°C and the temperatures for the viscosities, 251, 1000, 2510, and 10,000 poises, were determined. The viscosity depends mainly on the SiO_2 content of the rock; obsidian, with 73.8% SiO_2, has the highest viscosity, while the basic rocks, basalt and diabase, show the lowest values. The dependence of viscosity on temperature varies with the material. M.H.

X-ray investigation of the glassy state. N. Valenkov and E. Poray-Koshitz. *Nature*, **137** [3459] 273–74 (1936).—The authors found a gradual change of the diffraction pattern on transition from vitreous silica to a crystalline mixture of cristobalite and tridymite. The same gradual transition was observed from heated soda-silica glasses to devitrified batches of these glasses. Their observations prove the lack of a sharp boundary between the glassy and crystalline states, and their experiments demonstrate the gradual growth of crystallites and support Randall's crystallite theory. 5 diffraction patterns. J.L.G.

BOOKS AND BULLETINS

Calculating glazes and mixes for fine ceramics. A. I. Iosevich and N. I. Okun. Ukrgizlegprom., Kiev, 1934. 62 pp. Price 1R 50k. This booklet deals with basic raw materials, calculating materials and mixes and glazes, and graphic calculation of mixes and glazes according to Orlov's method. M.V.C.

Hutchinson's Technical and Scientific Encyclopaedia: Edited by C. F. Tweney and I. P. Shirshov. **Vol. 3, Hydrogen-Ion Concentration (*continued*) to Petrol.** Pp, 1345–1920. Price 24s. **Vol. 4, Petrol Engines to Zymurgy and Bibliography.** Pp. 1921–2468. Price 20s. Hutchinson and Co., Ltd., London, 1935. Price of 4 vols. £5. Briefly reviewed in *Nature*, **137** [3454] 49–50 (1936). See *Ceram. Abs.*, **15** [1] 16 (1936). J.L.G.

Methods of chemico-analytical control in silicate industry. F. I. Perchik. Ukr. Gosudarstv. Isdatelstvo legkoi Promuishl., Kharkov, 1934. 19 pp. Price 90 kopeks. This pamphlet discusses the analysis of soluble glass and the volumetric determination of alkalis in silicates. M.V.C.

Viscosity of acid and basic open-hearth and cupola furnace slags in molten state. T. Matsukawa. *Taniguchi Foundation for Promotion of Industrial Progress*, 65 pp. (March, 1935); abstracted in *Jour. Iron Steel Inst.*, **132** [2] 387 (1935); for abstract see *Ceram. Abs.*, **13** [5] 133 (1934).

PATENTS

Method of purifying zirconium silicates. C. J. Kinzie (Titanium Alloy Mfg. Co.). U. S. 2,036,220, April 7, 1936 (July 1, 1933). The method of producing zirconium silicate from the treatment of ores containing zircon commingled with impurities comprises heating the ores mixed with an alkali metal bisulfate to render the impurities capable of mechanical separation from the natural zircon grains without decomposing the latter, lixiviating the resulting mass with water, removing the dissolved salts and precipitated impurities by elutriation, drying the undecomposed zircon residue grains, and finally subjecting the dried and elutriated zircon residue containing less than 97% $ZrSiO_4$ to concentration by dry separation to remove therefrom substantially all free silica and other remaining impurities.

Method of purifying zirconium silicates. C. J. Kinzie (Titanium Alloy Mfg. Co.). U. S. 2,036,221, April 7, 1936 (July 1, 1933). The method of purifying zirconium silicate to produce from granular zircon +99% $ZrSiO_4$ essentially free of iron and titanium, comprises finely milling the zircon, and then heating the finely milled zircon mixed in intimate contact with a limited amount of carbon in the presence of a halogen gas in an amount in excess of that required to reduce and volatilize the impurities in the zircon, including substantially all the iron and titanium, but without materially affecting the thereby purified zirconium silicate.

Production of antimony oxide. J. O. Betterton (American Smelting and Refining Co.). U. S. 2,035,454, March 31, 1936 (Jan. 30, 1933; renewed July 10, 1935).

Treating impure antimony trioxide. J. O. Betterton and R. D. McLellan (American Smelting and Refining Co.). U. S. 2,035,453, March 31, 1936 (July 29, 1932).

General

Brick, tile, and pottery manufacture in New Zealand. J. W. Butcher. *N. Z. Official Yearbook*, **44**, 422(1936).—In 1934, there were 43 works employing 467 persons. Salaries and wages amounted to £82,664; cost of materials, £14,279; other expenses, £81,678; total value, £212,263. Brick made numbered 11,183,556 common and 461,616 fire brick; value £63,465. The value of pottery was £117,880. H.H.S.

Ceramic Association of New York second annual meeting. Anon. *Ceram. Age*, **26** [1] 18 (1935). F.G.H.

Clay fired hard at 300°C. Max H. Kliefurth. *Brick Clay Rec.*, **88** [3] 112 (1936).—By mixing a small amount of caustic alkali, either caustic soda or caustic potash, with the clay and then firing it to temperatures from 200 to 500°C, a product is obtained which approaches in hardness clay fired to a temperature near its fusion point. The resulting product is said to be resistant to the action of cold or boiling water for long periods of time, approaching in this respect clay fired at high temperatures. E.J.V.

Colloidal fuel. Editorial. *Indian Eng.*, **92** [8] 145 (1932).—An account of the successful experiment of burning the new oil-coal fuel in the Cunard steamship "Scythia" is given. A.P.S.

Direct photography of dust in the air. L. H. Ott and J. B. Ficklen. *Rev. Sci. Instruments*, **6** [1] 4–5 (1935).—The methods of determining the number of dust particles in air in common use today depend upon collecting the dust in water or depositing it on a glass slide. Objections have been raised as to the accuracy of the methods because of solubility or tendency of particles to agglomerate when

moist. Two general methods for the estimation of the amount of dust in the air itself have been worked out. The first depends upon the measurement of the decrease of illumination from a light source due to the presence of the dust. The second depends upon the amount of light that is scattered at right angles to the incident beam (Tyndall beam effect). The objection to these methods is that in counting the number of dust particles, the assumption is made that all of the particles are the same size. A method is described in which dust particles in the air are photographed using intense illumination of a photo-flash lamp. Illustration of the apparatus and pictures of dust particles (10 to 50 microns in longest dimension) are shown.
H.E.S.

Electric dust recorder. Mine Safety Appliances Co. *Eng. Mining Jour.*, **137** [1] 47 (1936).—The analyzer unit operates by breaking light from a single source into two separate beams of equal intensity which pass through moving picture film on to the active surfaces of photo-electric cells. The film is clear where the first beam cuts through it. After passing the first beam the film is moistened so that a jet of air, drawn from the enclosure under test, deposits any dust particles carried onto the sticky surface of the film. The film then passes through the second beam of light where the dust particles intercept and prevent some of the light from reaching the second photocell. Since the photocells are connected in opposition in a balanced electrical circuit, the difference between the potentials generated can be measured. A Leeds & Northrup recording potentiometer is furnished with the analyzer. A motor and pump for drawing samples up to 100 ft. away are integral with the analyzer. Illustrated.
J.L.G.

Employee training. H. P. Dutton. *Factory Management & Maintenance*, **94** [2] S182–96 (1936).—D. considers (1) the present-day need for training, (2) how a man learns, (3) what is to be taught, (4) type of instruction, (5) teaching procedures, and (6) six typical training plans. Illustrated. J.L.G.

Importance of ceramics. F. C. Flint. *Bull. Amer. Ceram. Soc.*, **15** [4] 154–55 (1936).

Industrial dusts. S. C. Blacktin. *Discovery*, **16**, 355–56 (Dec., 1935).—The study of dusts is proceeding in two directions, (1) by health hazards and (2) by konimetry, or methods of measuring particle frequency and size of dusts. See *Ceram. Abs.*, **14** [2] 57 (1935).
H.H.S.

Nepheline syenite. C. L. Cruikshank. *Bull. Amer. Ceram. Soc.*, **15** [4] 167–68 (1936).

Packing of particles: empirical equations for intermediate diameter ratios. A. E. R. Westman. *Jour. Amer. Ceram. Soc.*, **19** [5] 127–29 (1936); see also *Ceram. Abs.*, **9** [11] 990 (1960).

People who work in glass houses. Leonard Church. *Factory Management & Maintenance*, **94** [2] 79, ad. pp. 50, 52, 54 (1936).—The air-conditioning system and certain structural features of the new research laboratory of the Owens-Illinois Glass Co. at Toledo, Ohio, are described. Outside walls and inside partitions are made of glass blocks. These blocks are hollow, partially evacuated, translucent units of water-clear glass. Prismatic patterns or cuttings on the inside faces of the blocks control the light-transmitting and diffusing power. As much as 86.5% or as little as 11.7 of the incident light can be transmitted. No windows or window openings are necessary. Illustrated. J.L.G.

Physicist's picture of a true education. W. P. Davey. *Rev. Sci. Instruments*, **5** [1] 1–2 (1934).—The every-day work of the civilized world depends more and more on the results of scientific research. To be truly educated, one must not only have culture, but must also know the physical sciences and their applications. D. believes that the sciences also have a cultural value in that they reveal the greatest beauty ever shown to man, the beauty of the forces of nature. He lists three qualifications for an "educated man," (1) he must be able to get along with himself, (2) he must be able to get along with his fellow men, (3) he must be able to deal with the forces of nature about him.
H.E.S.

Physics in national planning. K. T. Compton. *Rev. Sci. Instruments*, **5** [7] 235–36 (1934).—Assuming that the objectives of national planning are the material, intellectual, and spiritual welfare of the people, C. believes that the developments of physics should be purposely accelerated. The science of physics has given birth to nearly all of those ideas, processes, and agencies which have brought man to an understanding of the material universe and to the use of its forces for his own purposes. Physics has produced civil, mechanical, and electrical engineering, a large part of chemical engineering, modern metallurgy, electrical communications, refrigeration, heating, ventilating, automotive and aeronautical engineering, and the countless products of those arts which have revolutionized modern life, not only in its material aspects but also in its intellectual, economic, and social relationships. Physics has not only originated these things but continues to develop them and should therefore be encouraged by national government policy. H.E.S.

Presidential address. J. M. McKinley. *Bull. Amer. Ceram. Soc.*, **15** [4] 153–54 (1936).

Scientific manufacture of ceramic building products: XIV–XVII. F. Chalamel. *Rev. mat. constr. trav. pub.*, No. 314, pp. 168–70B; No. 315, pp. 182–84B (1935); No. 316, pp. 6–9B; No. 317, pp. 22–25B (1936).—In the study of the preparation of the mix, conclusions are given of tests on the effect of the grain size, form of the grains, composition of the mix, different methods of preparation, manner of drying, and method of reducing mixes to an almost dry powder. Practical suggestions on the preparation of mixes in plants are given. Molding processes and their study are discussed. For Parts **XII–XIII** see *Ceram. Abs.*, **15** [3] 96 (1936). M.V.C.

Silicate of soda in the building industry. J. G. Vail. *Ind. Eng. Chem.*, **27** [8] 888–93 (1935).—Weather-resistant paints for glass, stone, etc., and permanent colors for roofing granules are prepared in a silicate vehicle. Anhydrous silicates are used in ceramic glazes and acid-resistant enamels. Thermal insulators are made by rapidly heating partially dehydrated silicates. Illustrated. F.G.H.

X-rays and silicosis. W. Kaempffert. *N. Y. Times*, p. 6 (March 8, 1936).—The X-ray method of determining

the composition of dust and its amount in air (Clark and Reynolds) to safeguard workers in dusty occupations is described. M.V.C.

BOOKS AND BULLETINS

Materials of Construction as Used in India, Their Nature, Production, and Use. NAGENDRA NATH MITRA. Calcutta General Printing Co., Ltd., Calcutta, India. 1930 pp., 407 tables and formulas. Price Rupees 10/-. The book is a standard work of reference, divided into eleven parts: (1) Stones: geological, scientific, and practical classifications; (2) Building Brick (clay, fireclay, sand-lime, glass, etc.): composition, brickmaking operations and machines, classification and characteristics, absorption and strengths, etc.; (3) Tile, Terra Cotta, Earthenware, and Stoneware: preparation of clay, potters' wheels, composition of clays for terra cotta, earthenware irrigation pipes, shapes, sizes, weights; (4) Sand, Sand-Substitute, Gravels, Flint, etc.: requisites of good sand, slags, ballast, stone breakers, crushers, fire resistance of aggregates; (5) Limes, Lime-Burning, Lime Products: classifications, characteristics, analyses, testing, plaster of Paris, burning limestone; mortar, common and hydraulic, slaking, grouting, lime concrete, tar and bitumen concrete, iron, lead and pumice concretes, lime plaster, lime painting, whitewash, distemper; (6) Hydraulic Cements, Concretes, etc.: pozzolana and Portland cements, slag cements, natural and artificial cements, cement calcining and grinding, testing, Portland cement mortar, strength, adhesion, cohesion, bearing and bursting strengths; plain cement concrete, materials, laws of proportions, making and depositing, strengths and weights, forms and molds, surfacing, coloring, building blocks, plastering over concrete, pebbling, specifications; (7) Asphalt, coal-tar, wood-tar, pitch, creosote, felt, ebonite, vulcanized rubber, gutta percha, rubberoid, Willesden paper, silicate cotton, asbestos, asbestos slates, Uralite, glue gelatine, etc.; (8) Timber: growth and structure, classification, characteristics, conversions, seasoning, preserving, chief Indian and foreign woods, soft and hard woods, tests, strengths; (9) Metals, metallurgy: iron and steel, copper, lead, zinc, cadmium, tin, nickel, cobalt, antimony, bismuth, arsenic, aluminium, magnesium, manganese, chromium, molybdenum, tungsten, vanadium, tantalum, titanium, zirconium, thorium, sodium, potassium, barium, calcium, gold, silver, mercury, platinum, iridium, palladium, rhodium, alloys, properties, ore smelting, refining, casting, rolling, hardening, tempering, welding, soldering, galvanizing, sherardizing, plating, enameling, gilding, forms of manufacture and marketing, properties of metals, strengths, loads, stresses and strains, ductility, malleability, fusibility, etc.; (10) Paints and Varnishes: bases, vehicles, solvents, pigments, driers, coloring, resins, gums, balsams, shellacs, copals, mixings, etc. (11) Glass and Miscellaneous: raw materials, silicas, flints, sheet glass, fluted, picture, plate glass, furnaces, polishing, annealing, glazing, etc., wall and ceiling papers, standard fabric and metal lining, waterproofing compositions, asbestos, corrugated sheetings, lincrustas, emery cloths and papers, etc. Complete index of 130 pages.
A. P. SOM

Physical methods for estimating the dust hazard in industry. H. L. GREEN AND H. H. WATSON. H. M. Stationery Office, 1935. Price 1s. Reviewed in *Engineering*, **140** [3629] 125 (1935). H.E.S.

Review of literature on effects of breathing dusts with special reference to silicosis: II-B. D. HARRINGTON AND SARA J. DAVENPORT. *Bur. Mines Information Circ.*, No. 6848 (July, 1935). 90 pp. Free. Abstracts and quotations from literature on dust diseases collected from many sources are presented. *Ibid.*, No. 6857. 57 pp. Free. For Part II see *Ceram. Abs.*, **14** [9] 236 (1935). R.A.H.

Silicosis as affecting workmen and operations. D. HARRINGTON. Read before fall meeting of Amer. Inst. Mining and Metallurgical Engrs., San Francisco; reprinted in *Bur. Mines Information Circ.*, No. 6867, 14 pp. Free. The fact that prevention of ill health in mining is just as definitely an engineering problem as prevention of accidents is emphasized. R. A. HEINDL

Handbook for Ceramists, 1936 (Taschenbuch für Keramiker). **Vol. I. Technical part.** 432 pp. **Vol. II. Notebook-calendar.** 32 pp. text. Published by Chemisches Laboratorium für Tonindustrie & Tonind.-Ztg., Berlin. In German only. Price 3.30 Rm. Volume I is devoted to ceramic products, excluding glass, and discusses the latest developments and studies dealing with (1) shaping, (2) drying, (3) furnaces and combustion, and (4) production methods. Enamels and properties of clays and kaolins are included. Literature and alphabetical indexes of corporations and companies related to the ceramic industry and other useful data are given.
M.V.C.

PATENT

Method of producing a ceramic body. R. C. BENNER AND H. N. BAUMANN, JR. (Carborundum Co.). U. S. 2,036,190, April 7, 1936 (Dec. 30, 1932). The steps in the method of fabricating ceramic articles whose normal use involves the experience of sudden temperature changes comprise forming an article of a vitrified alkaline earth silicate and causing the vitrified material to devitrify to form a body having a coefficient of expansion of less than 2.5×10^{-6}.

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Ceramics is a world-wide industry. Technological and scientific literature of importance to American ceramists appears in many languages. How is this material gathered from all parts of the world, condensed, and published in the monthly issues of *Ceramic Abstracts* issued by the American Ceramic Society?

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Situated in many foreign countries, England,

Belgium, France, Czechoslovakia, the U.S.S.R., India, Australia, and Japan, as well as in Canada and the United States, more than fifty-five abstracters each month scan the periodicals and new publications on ceramics, submitting abstracts of all articles which seem of interest. Their work is a vital contribution to ceramic reference literature and these men work faithfully to keep the entries in *Ceramic Abstracts* up to date.

On the tenth of each month abstracts from these sources are received in the editorial office in Columbus, Ohio.

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To enable convenient reading of the abstracts by busy ceramists specializing in particular fields, classification of the abstracts is important. This is done by the Editor. Preliminary editing is also done at the time of classification. More than four hundred abstracts are selected for publication each month.

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Assistants then are given the classified abstracts for what is called "first reading." Working with Author and Subject indexes at hand and with files of the journal index for the past nine years within easy reach, these assistant editors scan each abstract, marking them for the printer and watching carefully to see that reprints of articles which have already been abstracted are eliminated.

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First reading finished, the abstracts are put in order and each one is entered on a separate journal card. Here is listed first the journal in which the original article appeared, the title of the article, author's name, abstracter's initials, and classification number in *Ceramic Abstracts*.

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An outstanding cause of confusion and occasional duplication of abstracts previously published in *Ceramic Abstracts* is the frequent republication in other foreign languages, without apparent credit to the original journal or author, of a foreign technical paper which has appeared in a journal regularly abstracted for *Ceramic Abstracts*. This is probably the most difficult kind of duplication to discover but each year many of them are eliminated in the editorial office.

With fifty-seven abstracters now abstracting five hundred and seventy journals regularly for ceramist readers, utmost care must be taken to prevent duplication of abstracts previously published. The following letters recently received from members of the Society indicate that most of the duplicates are being eliminated.

(From a member of one of the largest research laboratories in the United States): "I would like to go on record as saying that your office has accomplished wonders in the matter of avoiding duplication of abstracts during the past several years. Furthermore, I feel that an excellent job is being done in the editing of the abstracts."

(From a professor in a technical school): "In view of the fact that we are placing all of the abstracts in a card index file, we have an excellent opportunity of checking on duplicates because they would naturally be filed under the same heading. While we do find duplicates from time to time, I would say that there are only three or four a year, which is a surprisingly small number considering the total number of abstracts handled and the number of abstracters that are doing the work."

During the first six months of 1936, 2796 abstracts were published. At this rate, during the whole year, more than five thousand abstracts from current ceramic literature will be made available to ceramists through *Ceramic Abstracts*.

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